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Analysis of User Preferences for Film Grain Noise in Images and Video Sequences

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Abstract

Film grain is an artifact of analog photography caused by the silver halide process that, for a variety of reasons, movie directors and photographers want to preserve in the digital age. We conducted an empirical study to determine user preferences for the amount and type of noise added to still images and video. We selected a diverse set of images and video sequences covering a variety of subjects and signal properties. We then added different amounts of film grain noise and white Gaussian noise. Pairwise comparisons of still images show that users prefer film grain over Gaussian noise only at one intermediate level of noise; at low-level noise, the preference of film grain over white Gaussian noise is not statistically significant; there is no clear preference at the highest level of noise. Pairwise comparisons between different levels of film grain and white Gaussian noise show a clear (statistically significant) preference for the lower amount of noise in all cases. For video sequences, we compared two levels of film grain noise to noise-free sequences. The results indicate that users prefer noise-free video over both levels of film grain noise, and lower over higher level of film grain noise.

Introduction

Film grain is an artifact of analog photography caused by the silver-halide process. In digital photography, there is a considerably lower amount of noise and has different characteristics, namely, thermal and shot noise. For a variety of reasons, photographers and movie directors want to preserve the film grain noise of analog photography or to add synthesized film grain noise to digital content. The reasons vary from nostalgia to perceived sharpness, richness of tones, to artistic effects. However, the focus has been on the content generators and the creative process. The goal of this study is to determine user preferences. While the addition of a small amount of noise has been known to increase perceived sharpness, our study has provided no indications of such an effect. In contrast to photographers and directors, our study indicates that users prefer noise-free content or low amounts of noise.

Our objective is to determine user preferences for different amounts and types of noise added to a variety of image and video content. We also wanted to determine whether the addition of film grain or other noise has a sharpening or other effect on image perception. In our empirical study, we considered three main problems: (1) the impact of different levels of noise; (2) the impact of the noise characteristics (film grain versus white Gaussian); and (3) any effects that noise may have on image sharpness and richness of tones.

While there is a lot of interest in film grain noise, the focus has been on the preservation or simulation of film grain noise. In particular, there has been interest in preserving film grain in video distribution, because the preservation of film grain requires high bit rates or noise removal and resynthesis at the receiver. To the best of our knowledge, the focus has been on creator (photographers, movie directors) preferences, not on user preferences, which is the goal of our study. However, in future work we would like to include content creators in our empirical studies.

We designed and conducted empirical studies, for both still images and video sequences. For the still image study, we selected a diverse set of images that include a face, a busy still life with fruit, plants, and a bicycle, a busy outdoor scene of an archaeological site, an image of boats in calm water, and a sunset picture of the Golden Gate bridge. We added three levels of synthesized film grain noise and three comparable (same standard deviation) levels of additive white Gaussian noise to each of the noise-free images. We then showed users different levels and types of noise applied to the same image and asked them to select the one that they liked best. For the video experiment, we used two levels of synthetic film grain noise, which we added to a diverse set of video clips. The video presentation was sequential, and the users were asked to select the one they liked best, after observing both clips.

The results of our empirical studies indicate that user preference decreases with noise intensity for both film grain and white Gaussian noise. For the same level of noise, there is a slight preference for film grain over white Gaussian noise, but it is not statistically significant. For highly textured images, it is difficult to distinguish the effects of noise. Some of the participants indicated that a moderate amount of film grain noise can increase texture and aesthetics, but too much noise is not desirable. In addition, the preferences sometimes depend on gaze. For video sequences, the results indicate that users prefer noise-free video over both levels of film grain noise, and lower over higher level of film grain noise.

Empirical Studies

We desgigned two empirical studies, one for still images and one for video sequences. For the still image study, we use selected a diverse set of images shown in Figure 1. We added three levels of synthesized film grain noise and three comparable (same standard deviation) levels of additive white Gaussian noise to each of the noise-free images. For the film grain synthesis we used a direct implementation [1] of the physics-based random-dot model [2], rather than the computationally intensive Monte-Carlo simulation of Newson *et al.* [3, 4]. We then showed users different levels and types of noise applied to the same image and asked them to select the one that they liked best. We did not specify any other criteria for their selection. Each image pair was presented for 1 second, but there was no time lime for making a selection after the images disappeared.

For the video experiment, we used 5 video clips with diverse content provided by Netflix. For the video experiment, we added

Figure 1. *Still images used in the empirical study. Left to right: "Lion's Gate," "Bike," "Woman," "Golden Gate," and "Nafplio"*

Figure 2. *3 levels of film grain noise added to "Bike" image*

Figure 3. *3 levels of Gaussian noise added to "Bike" image*

two levels of synthetic film grain noise to each of the video clips. The video presentation was sequential, and the users were asked to select the one they liked best, after observing both clips.

Analysis of the Results

Thurstonian analysis of the results of the still image study shows that preference decreases with noise intensity for both film grain and white Gaussian noise. The participants clearly prefer images with less noise. For the same level of noise, there may be a slight preference for film grain over white Gaussian noise, but t-tests suggest that it is probably negligible. For images rich in texture (Lion's Gate and Bike), it is difficult to distinguish the effects of noise (smallest range in the z-scores). Some of the participants indicated that a moderate amount of film grain noise can increase texture and aesthetics, but too much noise is not desirable. In addition, the preferences sometimes depend on gaze.

For the video sequences, we compared two levels of film grain noise to noise-free sequences. The results indicate that users prefer noise-free video over both levels of film grain noise, and lower over higher level of film grain noise. In all cases, we used the binomial test to determine statistical significance. Our empirical studies did not indicate any sharpness enhancement due to film grain or white Gaussian noise.

Finally, the specific application and goals are important. Some photographers and film directors prefer film grain noise; the movie content and the time it was made may also have an impact on people preferences.

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