“Less is more”: how understanding the process of motion picture film scanning can make your life easier

Abstract
Since the advent of the Digital Intermediate (DI) and the Cineon system, motion picture film preservation and restoration practices overcame an enormous change derived from the possibility of digitizing and digitally restoring film materials. Today, film materials are scanned using mostly commercial film scanners, which process the frames into the Academy Color Encoding Specification (ACES) and present proprietary LUTs of negative-to-positive conversions, image enhancement, and color correction.

The processing operated by scanner systems is not always openly available. The various digitization hardware and software can lead to different approaches and workflows in motion picture film preservation and restoration, resulting in inconsistency among archives and laboratories.

This work presents an overview of the main approaches and systems used to digitize and encode motion picture film frames to explain these systems’ potentials and limits.

Introduction

Since the advent of DI and the Cineon system, the way to preserve and restore motion picture film has seen an enormous change derived from the possibility of digitizing and digitally restoring film materials. Today, film materials are scanned using mostly commercial film scanners, which process the frames into the Academy Color Encoding Specification (ACES) and present proprietary LUTs of negative-to-positive conversions, image enhancement, and color correction.

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Digitization systems and technologies

Commercial film scanners are characterized mainly by the usage of film scanning and the different digital encoding systems. As for many other acquisition systems, the main differences among scanners are based on the purpose of the system, while all the other scanners are considered just prototypes if they are designed for commercial or archival purposes. Here, prototypes are divided into two categories if they are designed for commercial or archival purposes.
Among other defined conditions (see further), in some cases, the specific conditions can be controlled by the system as ADX, from a negative analog film through processing (e.g., digital image enhancement or the application of specific gamma curves in modern film stocks).

Nevertheless, this analog system with digital intermediate allows significant data manipulation. A trustworthy digital intermediate system simulating the printed positive copy optically generated through the spectrophotometer. In a few words, this system allows the generation of a white point digital negative which must be very useful for film digitization for restoration and preservation purposes (under specific conditions that will be met in the future).

This digital negative is composed of a spectral responsivity, and the specific spectral responsitivity furnished by the film manufacturer (for cinematographic negative or interpositive film) is fundamental (as Cineon previously) to correlate the exposure value registered by the sensor with film density values on specific frames to be used for digitization positive film systems.

In the FIAF scanner list, cinematographic film materials (positive or negative) is fundamental to notice that the possibility to integrate into scanners, the main decisions that will affect the digitization process (MAN). This section reports an experiment to assess and better explain the digital intermediate system for digitizing negative or interpositive film materials.

**Results**

In the results, the relationship between the film digitization and its quality standards is fundamental. Consequently, in the domain of motion picture film, the quality standards for digitization time and higher quality images are totally left in the hands of the producers, who are responsible for output quality. However, in the domain of motion picture film, the quality standards are totally left in the hands of the producers, who are responsible for output quality. Therefore, in the domain of motion picture film, the quality standards are totally left in the hands of the producers, who are responsible for output quality.

**ADX color film system**

In the context of the Academy Density Exchange (ADX) system, the relationship between the film digitization and its quality standards is fundamental. Consequently, in the domain of motion picture film, the quality standards are totally left in the hands of the producers, who are responsible for output quality. Therefore, in the domain of motion picture film, the quality standards are totally left in the hands of the producers, who are responsible for output quality. Furthermore, in the domain of motion picture film, the quality standards are totally left in the hands of the producers, who are responsible for output quality. However, in the domain of motion picture film, the quality standards are totally left in the hands of the producers, who are responsible for output quality.

This section reports an experiment to assess and better explain the linear signal acquired by the scanner’s sensor, which is transformed into scanners”, the main decisions that will affect the digitization process of a test performed on grayscale densities of a KODAK Color Transparency Scanner with different automatic and semi-automatic parameters. This scanner has been selected since it is among the most used professional scanners.. This section reports an experiment to assess and better explain the quality standards. Considering more rigorous system calibrations, intervene in case of errors, and publish the scanner operator guidelines with systems features and testings. Considering more rigorous system calibrations, intervene in case of errors, and publish the scanner operator guidelines with systems features and testings.

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In this case, the NEG scanning should not have been performed using the ADX system or applying film spectral responsivities during digitization. The negative analog film contains all the information related to his materials, and linear scanning should have been preferable to preserve the analog film information without further processing the images.

Considering the LIN scanning, the obtained output images present a logarithmic distribution, faithful to the densities distribution of the analog film. In this case, the output frames can be considered "as much faithful to the original as possible" since the ADX encoding is not performed. In this case, some proprietary in-processing LUTs can still be applied, but the obtained images can be considered "raw" and proportional to the signal registered by the sensor.

Discussion

Considering the example reported in the previous section, it is important to notice that linear scanning can result in more consistent and replicable digitization results among different laboratories. The automatic and manual digitization strongly depend on the processing implemented and operated by the scanner software. The ADX encoding can be very useful for modern film materials since we can reproduce and simulate the colors and tones of the corresponding positive film, reproducing its spectral characteristics. Understanding the image processing behind this operation is essential to make the digitization process straightforward and transparent. So, it must be clear that the image obtained is not a linear conversion of the negative film but a simulation of the positive, related to the use of a specific light source, specific negative materials, and a specific positive printing system (defined in [15]).

Linear scanning is preferable when the acquisition aims to obtain a digital image “as it is,” thus, a negative image from a negative film or a non-processed positive image. But in this case, it must be mentioned that a further manual image processing step must be conducted. The obtained linear image represents raw data, which must be edited and adjusted depending on archival needs; thus, a post-processing step is necessary. In this case, the suggestion is to digitize the analog film linearly using the default light parameters (or any other parameters suggested by the scanner’s production companies) and define a controlled and supervised post-processing step considering the restoration or preservation aim. Performing linear scanning can also allow the user to assess the scanner’s overall quality using high-density film materials or changing the acquisition parameters to define the scanner’s sensor limit (e.g., many scanning systems cannot correctly register density variations under 3.5 on color film materials). Understanding the scanner’s limit is essential because different film materials can...
This system is among the most used to perform RGB encoding of modern film stocks. Considering colors and tone reproduction, the ADX system is a useful solution, but if it is not known, each film material is known (e.g., for modern film). In that case, a more simple and linear scanning is suggested outside the scanner software environment. So, having “less” proprietary LUTs, could be useful for setting our processing methods, which take into account archival needs. In this case, for heritage Cinematographic film materials, as it is done for other cultural resources, applying extensive analog-to-digital conversion (ADC) and record modern films, as well as the ADX system allows correct overall system can present several issues that could lead to acquisition errors. As explained in the example reported in this work. Since scanners have been coupled with a customized post-processing operated by scanner software, which often uses processing could imply just some simple color balance or the application of a gamma, keeping all the operations of image edition. But what about historical films?

### References

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### Conclusion

In summary, film scanners are derived from the digital industrial boost, and this forced many archives and laboratories to implement the technologies and systems used in motion picture production. Considering colors and tone reproduction, the ADX system is a useful solution, but if it is not known, each film material is known (e.g., for modern film). In that case, a more simple and linear scanning is suggested outside the scanner software environment. So, having “less” proprietary LUTs, could be useful for setting our processing methods, which take into account archival needs. In this case, for heritage Cinematographic film materials, as it is done for other cultural resources, applying extensive analog-to-digital conversion (ADC) and record modern films, as well as the ADX system allows correct RGB primary lights with wavelength peaks on the ADX’s spectral responsivity, scanner lights are usually unsatisfying from an aesthetic point of view, but also untrustworthy. As explained in the example reported in this work. Since scanners have been coupled with a customized post-processing operated by scanner software, which often uses processing could imply just some simple color balance or the application of a gamma, keeping all the operations of image edition.
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