A Film in a Frame: Movie Barcodes for Film Restoration

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Abstract

Today, color reproduction techniques are among the most studied and fascinating topic in cinema studies and film restoration. In this study, we propose the use of a tool called movie barcode in order to represent the chromatic variation of a whole film in a single image. The movie barcode is a graph where all the colors used in each film frame are extracted and represented in succession, allowing to synthesize in a single image the chromatic variations throughout the film.
The study and analysis of the movie barcodes allowed us to extract movies chromatic mood board and make comparisons among different videos. The potential of this method has been initially tested on animated films with simple color compositions and next on digitized analog films. This application let us to evaluate the effectiveness of movie barcodes to represent and study films of cultural and historical interest before and after the process of restoration.

Keywords: *Color in Film, Film Restoration, Color and Cinema*

INTRODUCTION

Since its origins, color in cinema has been used to give emphasis and relevance to movie content, and today, there are many threads of research aiming at analyzing the use of color in cinema history (Mazzanti 2012), (Mazzanti 2018), and as means of expression (Wang, et al. 2010), (Wilms and Oberfeld 2018) (Cohen-Kalaf, et al. 2021).

In this context, movie barcodes are a widely used way to summarize and extract the main color used in a film. The movie barcode is a graph where all the colors used in each movie frame are extracted and represented in succession. Thus, this method allows to quickly obtain information on the colors and tones of an entire sequence of frames. Movie barcodes applied on movies can be easily found in the literature, e.g., Moviebarcode (Tumblr 2021) and The Colors of Motion (Clark 2018). Even though in the majority of the cases those applications are used for artistic purpose, there are many applications using the movie barcodes to extract colors and create color maps (Gray 2013), or to study the use of colors in films (Cohen-Kalaf, et al. 2021), (Chen, Faden e Ryan 2021). These applications have been found extremely useful in the process of animation films production, because movie barcodes are an easy system for communicating visual storytelling ideas before any actual animation is done, and in the process of color analysis and film studies, because movie barcodes offer a synthetic visualization of the colors in a video (Otto, et al. 2018).

In this work we propose the use of movie barcodes to study and analyze not only modern and contemporary movies, but also to compare video streams before and after the process of restoration. In fact, this approach could help the restorer in assessing how much the process of color correction affected the whole mood-board of the original film, but also to identify an eventual color cast. In fact in film restoration, due to the lack of original trustworthy references, the color correction is left in the hands of the restorer under the supervision of the restoration project curator (Enticknap 2013) (Plutino 2020). In this context, even though some tools have been developed to assess the overall quality of the final restoration, the restoration color assessment is almost always done subjectively (Barricelli, et al. 2020). As a consequence, the movie barcode could be a supplementary tool to support the work of

the restorer and to underline the color enhancements and modifications introduced during the process of restoration.

In this work, different approaches, and statistical methods to generate movie barcodes will be presented, and the applications on film restoration will be discussed.

MOVIE BARCODES

In order to obtain different movie barcodes for different purposes, many software or web applications create the barcode extracting the average color of each movie frame. Nevertheless, this approach could be limiting, because the average color of a frame is not always the most representative. In this Section, different statistical methods to extract the dominant colours from film frames have been analysed and compared in order to define the best method of movie barcode construction.

Considering the color distribution in an image as a statistical distribution of numbers, we computed for every RGB channel the mean, the median and the mode. In this way, we obtained three different results, synthetizing the color distribution in images (see Figures 1-2).

This representation could be useful to analyze and study different images, videos and old films because it allows at representing:

Figure 1: Example of computation of the mean, median and mode color in the image "Starfish".

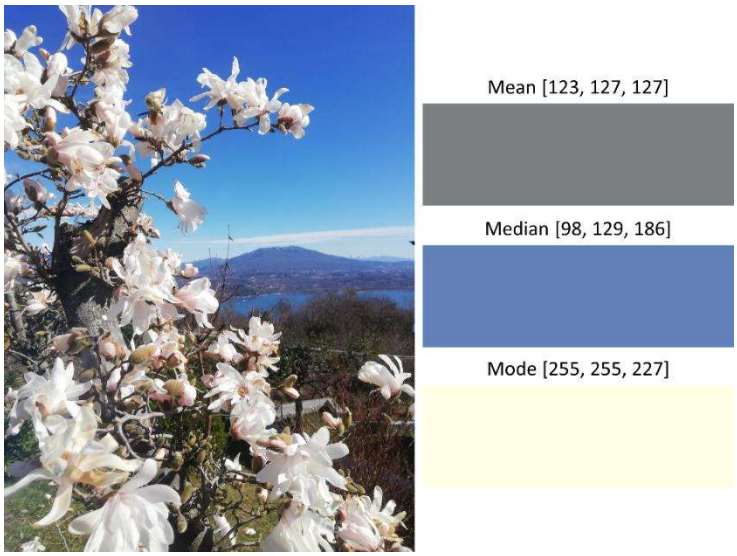

Figure 2: Example of computation of the mean, median and mode color in the image "Calogna".

The mean: the central value in the color distribution (i.e., the sum of all the values for every RGB channel divided by the number of pixels in the image).

The median: the middle value in the distribution (i.e., once ordered the pixel values in every RGB channel, the median value is the value in the middle of the distribution).

The mode: the most frequent value in the distribution (i.e., the value in every RGB channel which appears more often).

In order to apply this computation to video stream, once extracted the mean, median and mode for every frame in a video, we created a barcode where every column represents the mean, median or mode RGB value for every frame in the movie. An alternative approach to represent color distribution and analyze the chromatic content in films, has been presented in (Otto, et al. 2018), where the film frames have been posterized through a re-quantization process reducing the numbers of colors in every frame before performing the mean computation. Nevertheless, in this work we decided to exclude the posterization step, in order to include all the color content of the images in the computation and perform a more reliable analysis of the colors used in historical films.

FILM RESTORATION

The movies analyzed in this study are from the MIPS Lab (Computer Science Department, Università degli Studi di Milano) dataset. Many of these films have been restored using innovative color enhancement algorithms, named Spatial Color Algorithms (SCAs) (Rizzi e Bonanomi 2017). This family of algorithms, derived from Retinex, allow at enhancing frames colors according to the pixel spatial distribution, thus enhancing the colors and simulating their original appearance (Rizzi, Bonanomi and Gadia 2016). This approach has been successfully applied in film restoration and in the literature is possible to find many publications about its application (Plutino, Lanaro, et al. 2019), (Plutino and Rizzi 2020), (Plutino and Rizzi 2020b). In **Error! Reference source not found.** are resumed the ID, the main features and the employed restoration algorithm of the videos analyzed using the movie barcodes:

Video ID	*Main Features*	*Restoration algorithm*
Calza	363 frames Year: 1961	Automatic Color Equalization (ACE) (Gatta, Rizzi and Marini 2002)
Fiat	888 frames Year: 1931	ACE Manual Color Correction with Da Vinci Resolve (Black Magic Design 2020)
Nuit	130’520 frames Year: 1982	Manual Color Correction with Da Vinci Resolve

Table 1*:* List of videos analyzed using movie barcodes.

The videos named “Calza” and “Fiat” are just short sequences of longer videos (“La lunga calza verde” and “Fiat 508”). The video named “Nuit” is the full movie “Toute Une Nuit”, by Chantal Ackermann, restored in collaboration with the Belgian Cinematek.

MOVIE BARCODES FOR FILM RESTORATION

In Figure 3-5 are reported the results of the application of the movie barcodes on the movies presented in the previous Section. Here it is possible to see the difference among the mean, the median and the mode color and tones of the same film in original and after the restoration. In Figure

3, thanks to this representation it is possible to notice a strong red color cast around the frames from 80 to 90, where in this case is part of the video storytelling. In this video the strong pinkish dominant of the original film has been reduced after the color equalization and the strong pinkish shift evidenced in the mode barcode has been removed during the restoration.

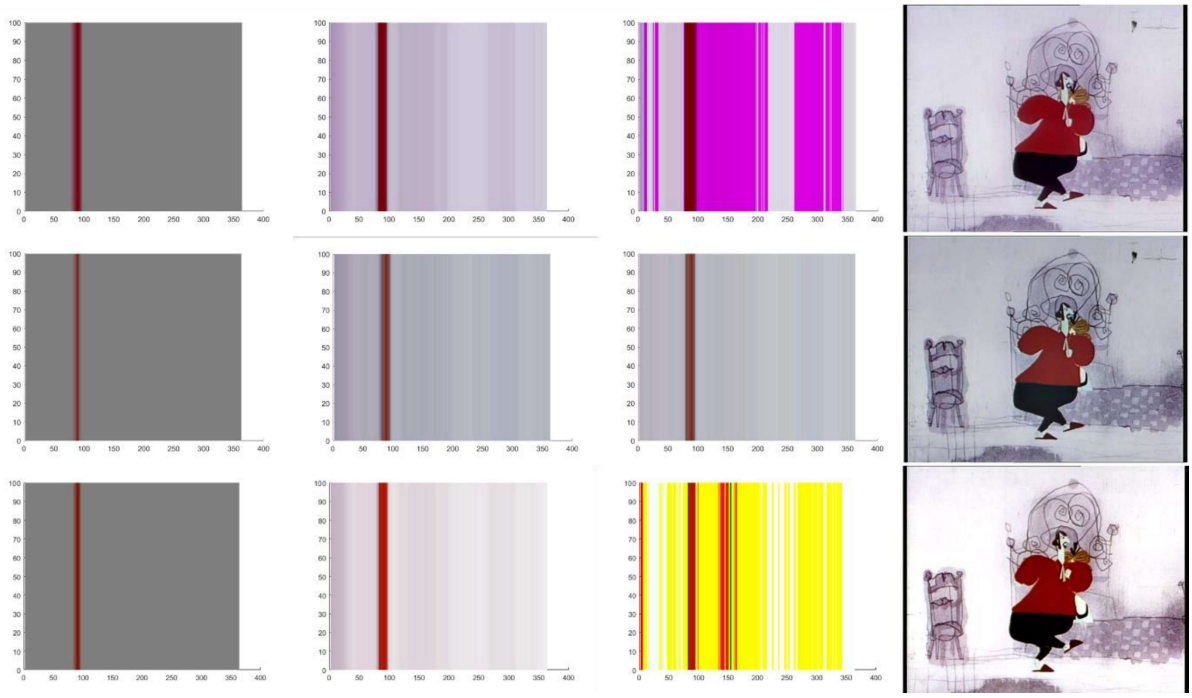

Figure 3: Barcodes of "Calza". From left to right it is reported the mean barcode, the median barcode, the mode barcode and a sample frame of the original and restored film.

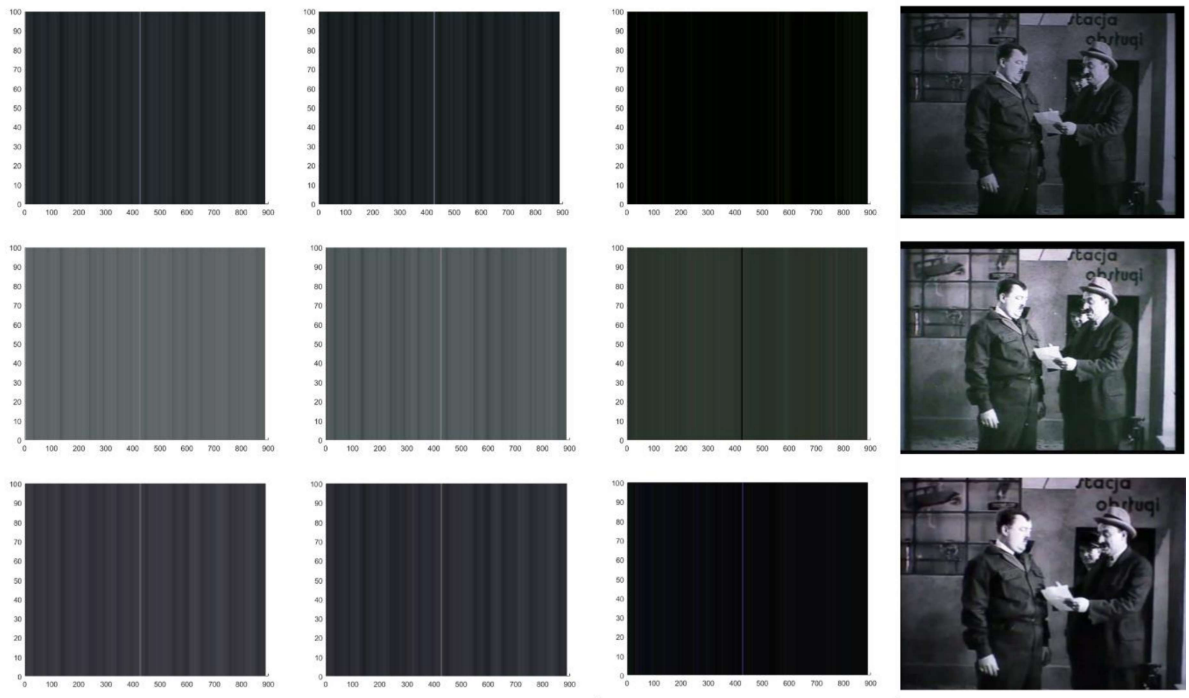

Figure 4: Barcodes of "Fiat". From left to right it is reported the mean barcode, the median barcode, the mode barcode and a sample frame. From top to bottom are reported the results of barcode application on the original film, on the film color correction through ACE algorithm and on the film restored manually.

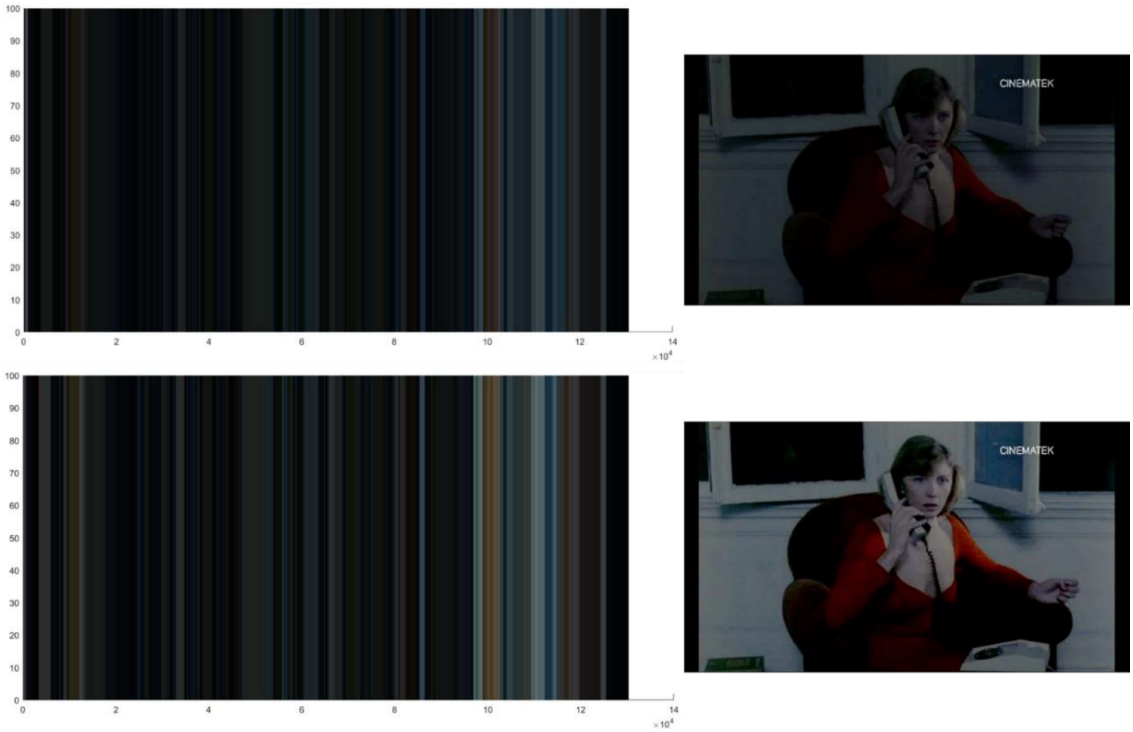

Figure 5: Barcodes of "Nuit". From left to right it is reported the mean barcode and a sample frame of the original and restored film.

In Figure 4, is presented an application of the movie barcodes on a black and white film. In this case the continuous shift among different shades of grey in the original mean and median barcode highlights a string flickering in the film, which has been reduced (not completely removed) after both the color corrections. Furthermore, the straight white line at the center of this sequence identifies a damaged frame in the video, which is totally oversaturated. In the restoration practice this possibility of detection could help the restorer in identifying strongly damaged frames to be substituted. In addition, the mode barcode is very useful to compare different restoration methods (see ACE and manual restoration), and to identify the brightness increase in the frames.

In conclusion, in Figure 5 is possible to see the application of the mean movie barcodes on a full movie. In this experiment, it is possible to see the color variance along with the whole film. Around frame 95'000 the increase in color brightness underlines the scene setting from night to daytime. The color correction produced an overall increase in color brightness, and the different scenes are more visible in the barcode.

CONCLUSION

In this work we have presented the use and application of the movie barcodes on a set of two film sequences and on a full film which have been restored using different color correction algorithm.

This preliminary study has been useful to demonstrate the potential of the movie barcodes computed with different statistical methods in order to visualize not only the mean color of every frame in a video, but also the median color and the most frequent color. From the analysis of the results, we have proven that the movie barcode could be a supplementary tool to support the work of the restorer. In fact, this method allows to underline the color enhancements and modifications introduced during the restoration process.

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