

## MOVIE BARCODE AS SUPPORT FOR VIDEO ANALYSIS AND FILM RESTORATION

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### Abstract

A movie barcode is a graph where the colors used in each frame are extracted and represented in succession. Since it is very intuitive, this tool is mainly used to represent movies and videos artistically and creatively. In this study, we propose the use of movie barcodes with a scientific and colorimetric approach, to summarize in a single image the chromatic variations of a movie. Thanks to this approach, it has been possible to extract movies chromatic mood boards and make comparisons among videos or different versions of the same video. The main potential of this approach is the possibility to study and test different methods of video enhancement and color correction, which could be useful not only in video processing but also in the domain of digital film restoration.

### Keywords

Movie Barcodes, Color in Film, Film Restoration, Color and Cinema

### 1. 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, *Chromatic Cinema: a history of screen colour*, 2012), (Mazzanti, *A few thoughts on the materiality of film*, 2018) and as means of expression (Wang, Li, Hu, & Wu, 2010), (Wilms and Oberfeld 2018) (Cohen-Kalaf, Lanir, Bak, & Mokryn, 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. The main advantage of this method is obtaining quickly 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 these applications are used for artistic purposes, 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, Lanir, Bak, & Mokryn, 2021), (Chen, Faden, & 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, Plutino, Lanaro, & Rizzi, 2018).

In this work, we propose the use of movie barcodes not only as artistic or creative representations, but also to compare video streams before and after the process of enhancement and restoration. In fact, movie barcodes could help the restorer in assessing how much the process of color correction or restoration affected the whole mood-board of the original film, but also to identify an eventual color cast. Film restoration is a complex and multidisciplinary discipline, where restorers must face different versions of the same films and where trustworthy references are often missing, incomplete or deteriorated. Consequently, the processes of film restoration and color correction rely on the expertise of the film restoration project curator and of the restorer (Enticknap, 2013) (Plutino 2020). In this way, 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, without objective assessments or measurements of image quality (Barricelli, Casiraghi, Lecca, Plutino, & Rizzi, 2020). In this context, the movie barcode could be an immediate



**Fig. 1:** Example of computation of the mean, median and mode color in a synthetic image.

tool to visualize and identify the alterations among different versions of the same film, or to immediately represent the color modifications introduced in the restoration process.

Thus, it could be a useful instrument to support the work of all the professionals working on a restoration project. In this study we present at first different approaches and statistical methods to generate movie barcodes (Section 2), then we briefly explore the topic of film restoration (Section 3) and subsequently we present and discuss some applications of movie barcodes on restored films (Sections 4 and 5).

## 2. Movie Barcodes

Many software or web applications create the barcode extracting the mean 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 colors from film frames have been analysed and compared in order to define different approaches on movie barcodes construction.

Considering the color distribution in an image as a statistical distribution of numbers, we computed the mean, the median and the mode of the color. In this way, we obtained three different results, synthetizing the color distribution available in the image (see examples in Figures 1-2). This representation could be useful to analyze and study different images, videos and digitized films because it allows to represent:

- 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 RGB triplet 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 modal RGB value for every frame in the video. An alternative approach to represent color distribution and analyze the chromatic content in



**Fig. 2:** Example of computation of the mean, median and mode color in the image "Seaside".



**Fig. 3:** Frames extracted from “Calza” coming from the original version (left) and the ones enhanced using ACE (center) and STRESS (right).

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.

### 3. Film Restoration

Film restoration is a complex process, which involves several steps and a wide variety of competencies and professionalism. Thus, in this work we will not focus on the different phases of the film restoration practice, but we will present an analysis of the results of the digital restoration step (mainly focused on color correction and enhancement). Today, color correction in film restoration is a process derived from a philological reconstruction of the color used in all the different versions of a film and done mainly manually using video processing softwares (e.g, Da Vinci Resolve (Black Magic Design, 2020)).

This classic approach can be combined with the use of automatic or semi-automatic image processing filters and correction algorithms (e.g, automatic white balance, LUTs), which could reduce the time of restoration and support the restorer.

The movies analyzed in this study are from the MIPS Lab (Computer Science Department, Università degli Studi di Milano) dataset. In Table 1 are resumed the ID, the main features and the employed restoration methods of the videos analyzed using mean, median and mode movie barcodes.

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

Video ID	Main Features	Restoration method
Calza	363 frames Year: 1961	<ul style="list-style-type: none"> <li>Automatic Color Equalization (ACE) (Gatta, Rizzi and Marini 2002)</li> <li>STRESS (Kolås, Farup, &amp; Rizzi, 2011)</li> </ul>
Fiat	888 frames Year: 1931	<ul style="list-style-type: none"> <li>ACE</li> <li>Manual Color Correction</li> </ul>
Motorist	4420 frames Year: 1906	<ul style="list-style-type: none"> <li>Manual Tinting and Toning</li> </ul>
Piazza	21343 frames Year: 1982	<ul style="list-style-type: none"> <li>ACE</li> <li>Manual Color Correction</li> </ul>

The videos named “Calza”, and “Fiat” are just short sequences of longer videos (“La lunga calza verde” and “Fiat 508”). The videos named “Motorist” and “Piazza” are the full movie “The (?) Motorist” (Walter R. Booth) and “The Funerals of the Bombing of Piazza della Loggia in Brescia” (M. Bertoli). The movie “Calza” and “Fiat” have been restored by the MIPS Lab using innovative color enhancement algorithms, named Spatial Color Algorithms (SCAs) (Rizzi & Bonanomi, 2017), which can be used as kick-off processing in the restoration (i.e., as preliminar filtering before the manual correction), or as automatic color enhancement. This family of algorithms, derived from Retinex, allow to enhance 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 (see enhancement examples in Figure 3) (Plutino, et al., 2019, Plutino and Rizzi, 2020, Plutino and Rizzi, 2021). In order to test the use of movie barcodes also on more classical color enhancement techniques, we applied this tool also to the film named “Motorist” and “Piazza”. The first one is a film made for Robert W. Paul, which originally could have presented tinting coloring (a version of the film is available on YouTube (Old Films and Stuff, 2021). In film restoration it may happen very often that restorers face with black and white versions (e.g., from negative copies) of films from the early cinema which could have presented manual coloring or early coloring processing on the positive copies. Thus, it could be interesting to use movie barcodes to represent the coloring digitally introduced during the restoration, to be compared with the original black and white copies or with other colored versions (Genaitay & Dixon, 2010), (Fossati, 2013), (Davis, 2019). In conclusion, the color correction of the film “Piazza” has been made manually and using ACE. Furthermore, the manual restoration has involved also operations of dust and scratch removal, image steady stabilization and noise removal (Plutino, Bellotti, Lombardi, Guerrini, & Rizzi, 2018).

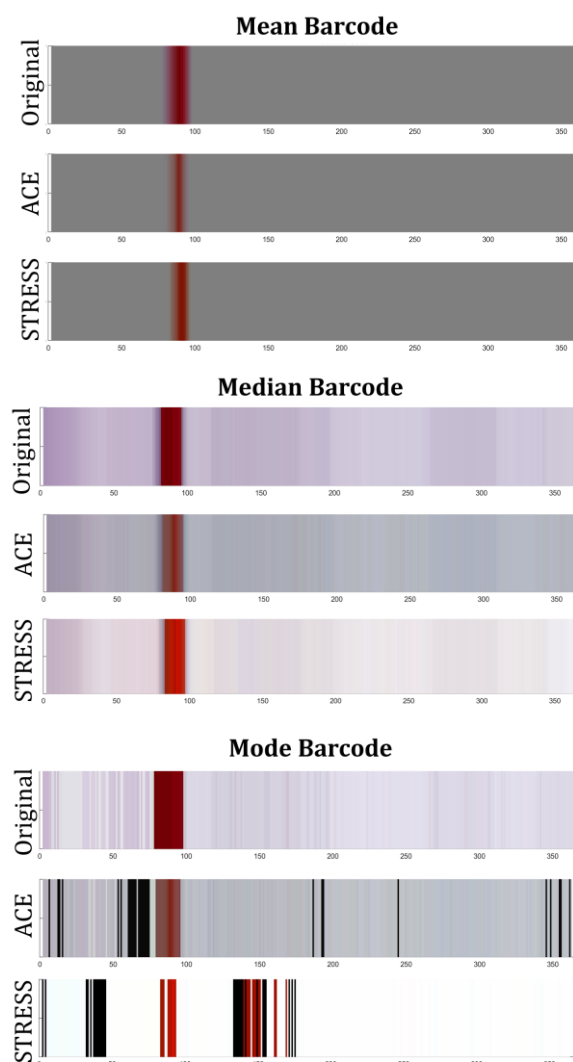
#### 4. Movie Barcodes for Film Restoration

In Figures 4-7 the results of the application of the movie barcodes on the movies presented in the previous Section are reported. 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 4, thanks to this representation it is possible to notice a strong red color cast around the frames from 80 to 90, which is part of the storytelling. In this video the strong pinkish dominant of the original film has been changed in two different ways using ACE and STRESS, as it is possible to see comparing the mode barcodes. In ACE, the colors have been equalized obtaining as color mode a medium gray, and in STRESS the colors have been balanced obtaining a white. This trend can be highlighted also in the median barcode.

In this analysis it is interesting to notice also the variation of the color mode among ACE and STRESS, since in this latter method, we have a strong presence of red dominant (which corresponds to the main character shirt, see Figure

3), also in some frames subsequent to the whole red scene. In addition in STRESS enhancement more frames with black as dominant color (which correspond to the character trousers and profiles) can be noticed. In Figure 5, an application of the movie barcodes on a black and white film is presented. 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. In these barcodes, the straight white line at the center of this sequence identifies damaged frames in the video, which are totally oversaturated. Thanks to the movie barcodes, it is very easy to identify shifts



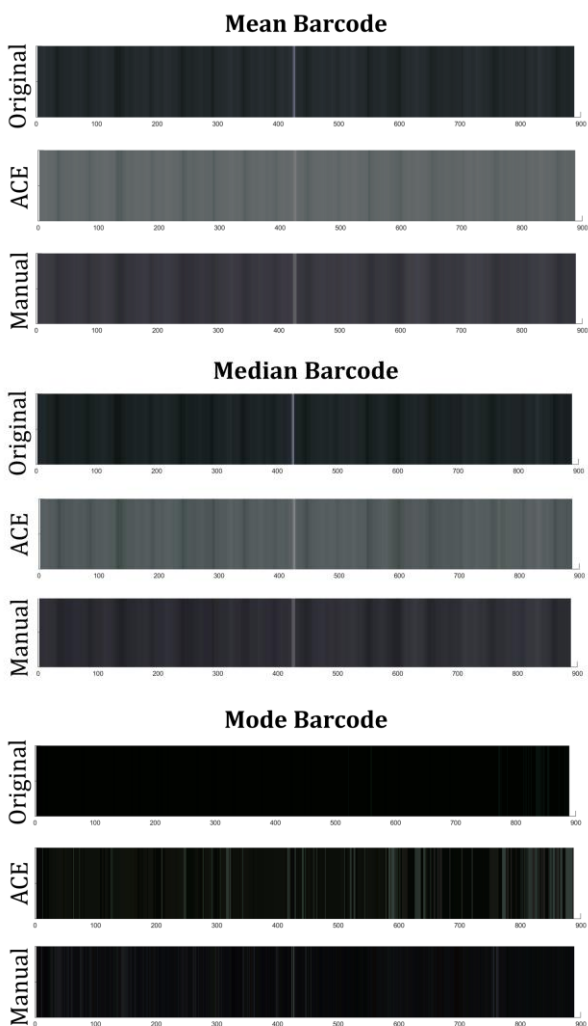
**Fig. 4:** Barcodes of “Calza”. On the top the mean barcodes from the original film, ACE and STRESS, at the center the median barcodes from the original film, ACE and STRESS and on the bottom the mode barcode for the original film, ACE and STRESS.

and alterations among frames and quantify the error reduction in the restoration practice.

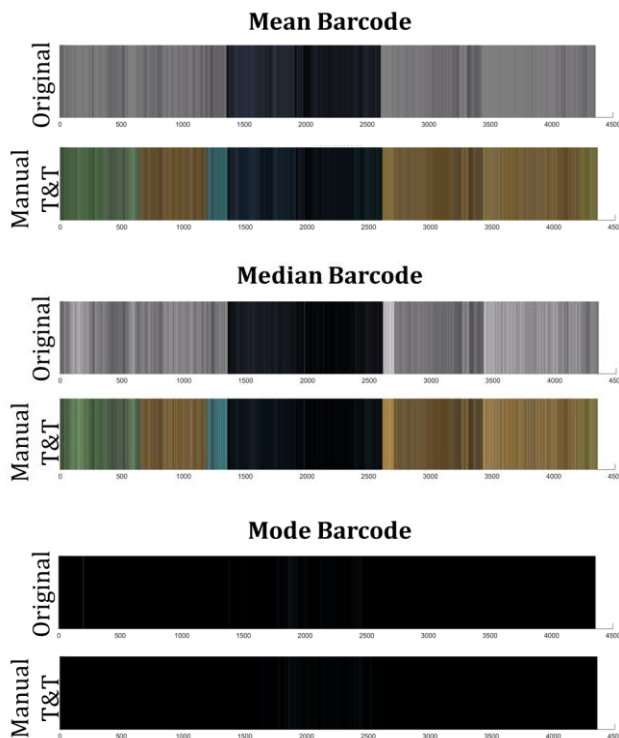
Considering the mode barcodes, it is interesting to notice the increase of variability in frames modal color produced by the manual and ACE enhancements. Those corrections, in fact, increase the details in the frames, thus introducing variations in the mode barcode which is completely black in the original film.

In Figure 6, the application of movie barcodes on a digitally tinted and toned film is reported. The original video is a black and white version of a film from 1906, which has been subject to a digital tinting and toning colorization. Considering the mean and median barcodes, it is possible to distinguish three main scene settings, which correspond to real-life scenes (the first and third

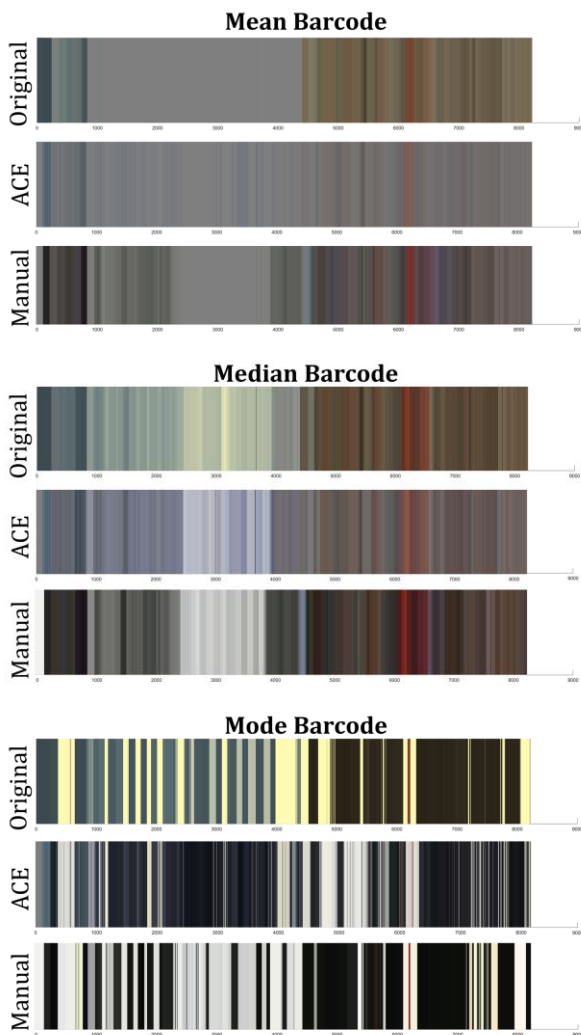
gray frame sequences in the original barcodes) and the fantastic setting (the dark central frame sequence), which corresponds to a fantastic scene where the car drives in the sky. Considering the barcodes of the manual tinting and toning, the first sequence has been divided into three parts colored with three different dyes (green, yellow and light blue), for the central sequence the coloring is in dark blue and for the whole last sequence the coloring is yellow. This color shift is evidenced by the mean and median barcode, while the modal color is black for all the different sequences. In this case the dominant color is related to the black profiles of the images and to the presence of black bars within the frames (due to a change in aspect ratio). In conclusion, in Figure 7 is possible to see the application of the mean, median and mode movie barcodes on the full documentary “Piazza”. In the mean and median barcodes is possible to appreciate the scene changes, in particular the video can be divided in two main parts: a first one whose mean color is gray and a second one which has ocre and red as mean and median colors. In this documentary, the scene subdivision is extremely important, because it defines the end of a first narrative sequence centered on the black and white photos taken after the historical



**Fig. 5:** Barcodes of “Fiat”. On the top, the mean barcodes from the original film, ACE and manual restoration, at the center the median barcodes from the original film, ACE and manual restoration and on the bottom the mode barcode for the original film, ACE and manual restoration.



**Fig. 6:** Barcodes of “Motorist”. On the top the mean barcodes from the original film and manual tinting and toning (T&T), at the center the median barcodes from the original film and manual T&T and on the bottom the mode barcode for the original film and manual T&T.



**Fig. 7:** Barcodes of “Piazza”. On the top the mean barcodes from the original film, ACE and manual restoration, at the center the median barcodes from the original film, ACE and manual restoration and on the bottom the mode barcode for the original film, ACE and manual restoration.

bombing of Piazza della Loggia, and the beginning of a second part focused on the funerals of the victims. In the mean and median barcodes, it is possible to see the symbolic relevance of the color red. Comparing the original, ACE and manually restored videos, in the mean and median barcode the increase of contrast given by the manual restoration, and the overall color balance given by ACE algorithm are represented. This latter trend is visible also in the mode barcode, where the yellowish color of the original frames (related to the deterioration of the film) is substituted by grays. In both ACE and Manual barcodes, the contrast of the images has been increased, but ACE intervened more in the first part of the video, while the manual restoration on the second one (this is

visible mainly by the dominance of frames with black as modal color).

### 5. Conclusion

In this work we have presented different applications on film restoration of a popular tool: the movie barcode. Movie barcodes can be generated using different statistical operations. In the considered application, the mean and median barcodes provide similar information, and the mean and mode barcodes can be considered the most interesting. The mean barcode can be useful to identify frame sequences and strong color casts which characterize the whole frames; thus, it can be useful to analyze the storytelling or the effects of a degradation process. On the other hand, the mode barcodes are useful to identify the color characteristics of the single pixels, thanks to the extraction of the most frequent RGB triplets.

In the tested applications movie barcodes have been found useful for several applications, like the analysis of different restoration algorithms (e.g., the comparison between ACE and STRESS in scaling the tones), the evaluation of different contrast enhancements in black and white or color films (e.g., see the comparison between manual restoration and ACE), or the visualization of video coloring processes in a single frame. Above all, the possibility to compare the original film frames with one or more restored versions could be extremely useful to assess the robustness of the restoration method along the film, but also to present and visualize the results in a single image. This latter case can strongly improve the presentation of restoration results, but also provide a simple and intuitive representation for cataloguing purposes or for restoration documentation. Since there are many different ways to represent color dominances, in future works it could be useful to test other metrics and statistics, or to represent not only the first dominant color, but also the second and third in succession, improving the work presented in (Otto, Plutino, Lanaro, & Rizzi, 2018).

With this first analysis we aim at inspiring film professionals and restorers in using alternative and creative ways to present their restoration results, which could be useful for representation but also to go through a more objective quality assessment and result evaluation.

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