Film Repository for Restoration (FiRe2): identification of photographic and cinematographic films

Beatrice Sarti [1,] *, Arianna Crespi [1], Giulia Morabito [1], Alice Plutino [1] and Alessandro Rizzi [1]

[1] MIPS Lab, Computer Science Department, Università degli Studi di Milano; beatrice.sarti@unimi.it; arianna.crespi3@studenti.unimi.it; giulia.morabito@studenti.unimi.it; alice.plutino@unimi.it; alessandro.rizzi@unimi.it

* Corresponding author: beatrice.sarti@unimi.it

Abstract

The identification and restoration of photographic and cinematographic films are often needed as they can undergo severe deterioration, aging, and color fading. Moreover, films also have to keep up with quick technological changes. In this context, knowing the material that composes the film is fundamental to restore the chromatic characteristics to their origins and to perform a correct retrieval faithful to the analog support. Nevertheless, the lack of technical information and the absence of open-source archives of the production companies underlines the actual and concrete need for a database of physical, chemical, and sensitometric data of films and photos. These are the motivations that lead to the creation of FiRe^2, a unique database of cinematographic and photographic materials that can support the work of conservators, restorers, and researchers. With this project, we also aim at promoting cooperation between institutions and professionals.

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

INTRODUCTION

Film preservation is a challenging process: it involves many different fields and merges both humanistic and scientific knowledge. It is a complex framework, which requires a multidisciplinary background.

The first step of film restoration is historical and philological research, as many different copies of the same photo or motion picture are usually available (e.g., some copies may have suffered censorship and others can present intertitles): understanding the historical context in which the original negative and the copies have been produced as well as the film philology reconstruction are fundamental aspects for a correct restoration. However, this type of information is not just the only to be considered since scientific data are essential both for conservation and restoration purposes.

Every (motion or still) picture is the result of the interaction of different cameras, film stocks (with their specific emulsion, dyes, and sensitivity), printing machines, and projection technologies. The varied combination of all these elements produces a different final image. In this way, analyzing, studying and understanding the chemical and physical properties of materials that compose the film and the technical features behind the photographic and cinematographic filmmaking are fundamental to set up a solid restoration workflow faithful to the original materials.

The latest step of this evolution is the introduction of digital technologies, which has led to a deep development in the acquisition and fruition techniques and a consequent improvement of the post-production process and film restoration. Since the superior manageability and reversibility of digital intermediate, more and more archives are embarking on massive digitization initiatives to improve the access to their materials. However, most of the time, the conversion from analog to digital is made without effective color control and management. This leads to issues in color reproducibility in digital systems, since not all the current display and projection devices can reproduce the same color palette of an analog film. Reconstructing the exact set of colors of the original films is therefore a challenging task, even more complicated by the lack of technical information (e.g., physical data about film dyes, emulsions and sensitivity).

All these needs, lead to the creation of a unique open-source technical database, to be used as a starting point for film restoration. The preliminary analysis made on the materials provided by a team of experts has led to a first film classification. Then, many existing databases have been merged and supplied with more information and a relational database has been implemented. To make it available for the community of restores and researchers a completely free website has been created (Photo FiRe^2), with the aim of promoting the sharing of data and the cooperation between professionals.

This work aims to raise awareness on the color reproduction problems that always affect the practice of digitization and digital restoration and to promote the collaboration between privates and institutions, to retrieve technical data that may be otherwise be lost.

THE MOTIVATION BEHIND FIRE^2

Over the years, the film industry has faced a lot of innovations: the development of different film base materials, the advancement of many acquisitions and projection instruments, as well as printing and developing machines. One of the most tangible and rapid changes has been the continuous introduction of new coloring techniques: indeed, since the invention of film, one of the great hurdles has been adding color to black-and-white motion pictures. Attempts to color films have been numerous and various during the years and many different techniques and dyes have been used (Read 2009), (Pierotti 2012), (Misek 2010), (Flueckiger 2012), (Rogers 2007).

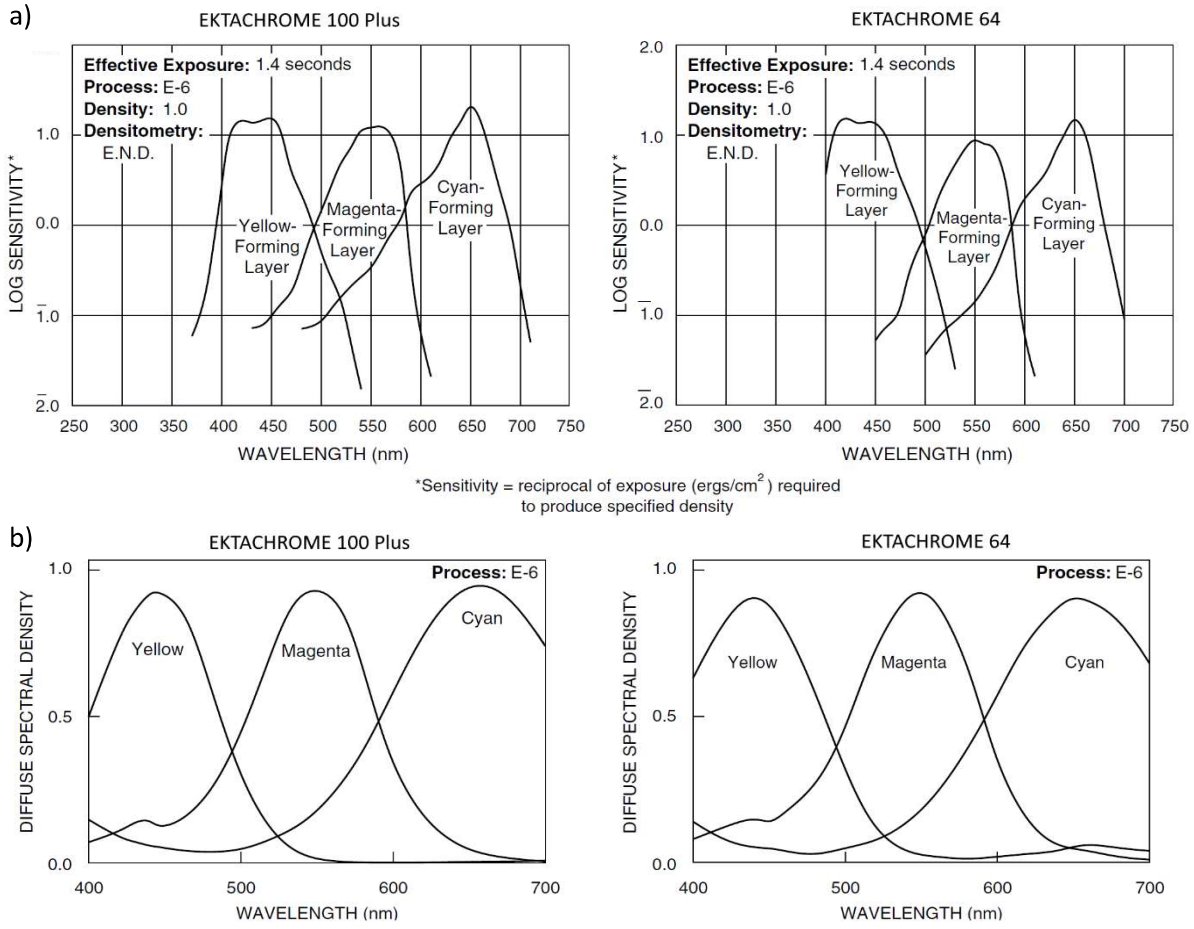

Figure 1: Comparison between the Spectral Sensitivity curves (a) and Spectral dye Density Curves (b) of two different reversal film stocks: Kodak Ektachrome 100 Plus Professional and Kodak Ektachrome 64 Professional.

Thinking about the images as separate and independent entities from the material of which they are composed is deeply wrong and can lead to incorrect conservation or unfaithful retrieval of the cultural object. Therefore, even though, the content of the film has always been considered more important than the support on which it relies on, the (motion or still) images are the result of the physical and chemical properties of the material of the film stock (with its specific emulsion, dyes, and sensitivity) and its interaction with light. That is because every film has a different gamut. In color theory, the gamut is the subset of colors that can be accurately represented within a given color space or by a certain device. To better understand this concept, Figure 1 shows the spectral sensitivity curves and the spectral dye density curves of two reversal films by Kodak: Ektachrome 100 Plus Professional and Ektachrome 64 Professional. The spectral sensitivity curves represent how the emulsion layers respond to a different wavelength of the electromagnetic spectrum. Higher values indicate a more light-sensitive emulsion (for example, the green curve for Ektachrome 64 is lower than that for Ektachrome 100 Plus, which can instead emphasize greens more), while the curve overlapping means a lower color saturation. The spectral dye density curves represent the percentage of absorbed/transmitted light as a function of wavelength. In the same way, the overlap in the curves leads to less-saturated colors in the resulting images and the evident differences between the two films implying that the same image produced by the two stocks will be different.

The concept of gamut and the relative color reproduction issues are even more evident nowadays with the advent of the digital intermediate and the development of digital technologies. The migration from analog to digital media leads to problems in color reproducibility in digital systems, since every reproduction instrument or projection technology, as well as every cinematographic or photographic film, has its own gamut. In Figure 2 is reported an example of this: in the CIE Chromaticity Diagram, the xy coordinates of the RGB primaries of Macbook air 12 monitor are compared to the once of a motion color negative film. The film stock has a wider gamut and consequently a common monitor cannot correctly reproduce its colors.

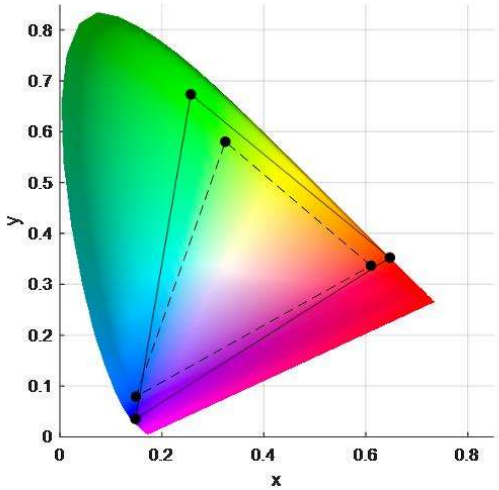

Figure 2: Comparison between the gamut of the Macbook air 12 monitor (dashed lines) and the Eastman EXR 200T color negative film (solid line).

This problem of color reproduction, even if it has been less studied, is clearly visible when comparing the original analog film and the digital media. Nowadays, to overcome this issue, film color correction is usually performed manually with a visual comparison. Nevertheless, even though the correction is performed by an expert, the subjectivity of the operations remains a limit in film restoration. In this context, the availability of technical and sensitometric data about the film would

make the preservation and restoration work easier and more objective: some errors in tones and color reproduction could be avoided and the specific film features could be supported by mathematical and physical models. From the spectral sensitivity curves and the spectral dye density curves of the films it is possible to build specific algorithms to reconstruct their gamut and to retrieve other colorimetric data. A possible outcome to this project is the creation of new LUT (Look-Up-Tables) to simulate the colors of a specific process, or the creation of film emulsions degradation models starting from the original film stocks datasheets. In this way some attempts have already been made (Gschwind and Frey 1997), (Rizzi et al. 2008) but many improvements need to be achieved in order to reproduce a faithful color film perception.

For all these reasons, the availability of such kind of information could be very useful in the restoration workflow and in the reproduction process to obtain a result faithful to the original film and materials. Production companies often provide informative datasheets of each film produced, which include all the technical features of the product as well as their sensitometric curves and the information for the film stock characterization. Nevertheless, these datasheets are not always available, especially for the oldest materials. The accessibility of information is indeed another problematic point. First of all, the openness of the archives is not always so obvious: many archives do not have public access or only provide partial information. Finally, while there is plenty of historical archives, the retrieval of scientific data is often hard.

FIRE^2: WEBSITE AND DATABASE

Many works have been already published, to index and organize the different techniques and materials used in photography and cinema history. Nevertheless, many technical information on sensitometry and emulsions have been lost. Even if some efforts have been made to create dataset collections and catalogs, very few works are open source and have been published. Starting from this need, different existing databases have been merged to create Photo FiRe^2. Sensitometric and technical information about films have been added, to provide a set of information as wide as possible.

The original materials on which the database has been built come from three main archives: the Historische Kleinbildfilm Datenbanke (Gschwind 2021), Nicola Mazzanti's film archive (Mazzanti 2019) and Historical Timeline of Film colors (Flueckiger 2012).

After the analysis and the classification of the films indexed in these datasets, research of additional information about them was made, leading to a collection of film-related files of various kinds. In order to distinguish the different films, an alphanumerical code has been developed, which allowed their unique identification.

Table name	Table content
Film	List of films with their main features
Attached Files	Film-related materials
Additional Material	General information not related to a specific film
Marketing	Materials related to Marketing & Advertising
Source	List of references
Film-Source	Table to make (N, N) relation between Film and Source
Log	To keep a record of the updates

Table 1: List of database tables.

To store all the data collected a relational database has been implemented. It is composed of seven enity-tables (Table 1), five of them store the results of the research (Film, Attached Files, Additional Material, Marketing and Source), the other two are used for the database construction (Film-Source, Log).

The Film table contains a list of technical data (Table 2). The Attached Files table contains technical datasheets and sensitometric graphics useful for defining the qualitative aspects of a film such as exposure, wavelength of the dye used, spatial frequency and spectral density of the dye (Figure 3).
All these data are useful to study the sensitometry of a film and to retrieve colorimetric information to perform a correct restoration.

ID code	Identification code of the film (primary key)
ID source	Serial number of the reference in the Table Source (foreign key)
Name	Film name
Brand	Production company
Date	Date of film stock production
Origin	Production country
Photo/Movie	Cinematographic or photographic film
Type	Color or black&white film / positive, negative, reversal film
Principle	Colouring principle
ISO	Film speed
Grain	Film granularity
Latitude	Film exposure latitude
Contrast	Film final contrast
Format	Film format (e.g. 16mm, 35mm)
N° Camera Film	Number if motion picture camera film
Soundtrack	Film with or without soundtrack
Use	General information about film use
Update	Date of the last update

Table 2: List of Film attributes.

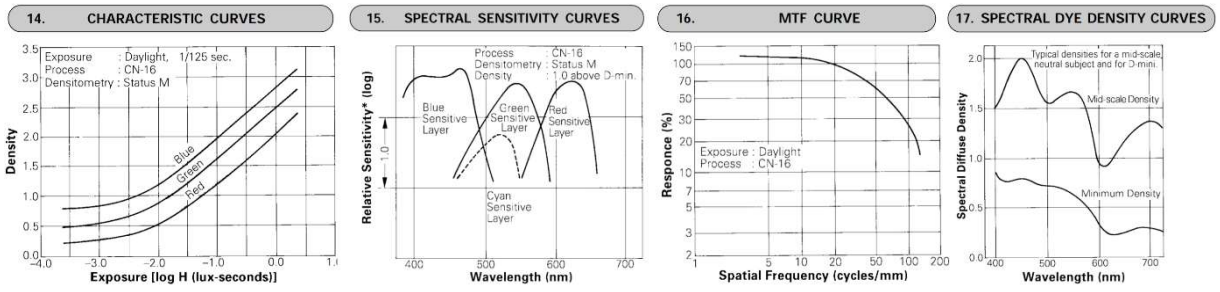

Figure 3: Example of sensitometric graphics of Fujicolor Superia 100.

To make this dataset accessible to the community, a website has been developed. It is available both in English and Italian and its structure is presented in Figure 4.

The Archive section is the backbone of the website: it is connected to the database and allows the users to explore the archive and look for information.

The possibility of involving other subjects in the research and creation of the archive is underlined in the Help us section, which is dedicated to anyone in possession of material useful to enrich the database: collaboration is very simple and takes place through a form compilation. There is always a control procedure for submitted material prior to publication.

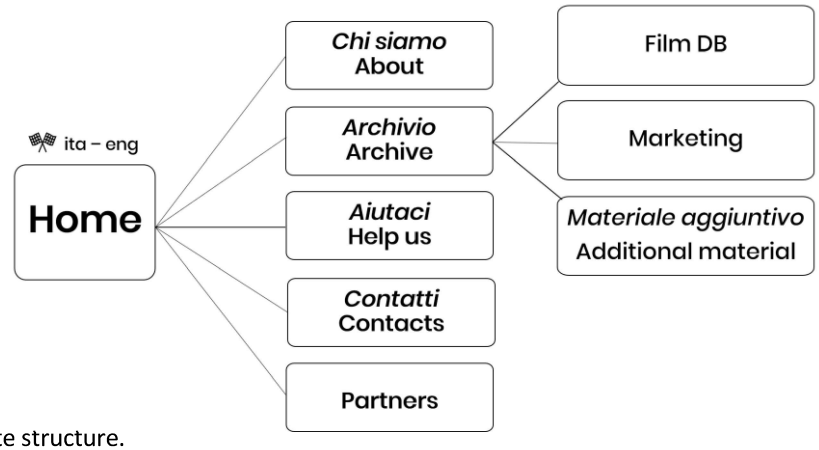

Figure 4: Website structure.

CONCLUSION

In this work we have presented the motivation behind the creation of FiRe^2, a large technical database that collects historical, technical, physical and sensitometric data of different photographic and cinematographic film materials.

This work intends to raise awareness of the need for retrieving and acquiring scientific data among conservators, restorers, and film professionals. Analyze, investigate, and comprehend the chemical and physical composition of films is crucial to properly conserve the film and obtain a faithful reconstruction for digital restoration.

Finally, the creation of this preliminary website aims to give a point of access for information sharing between experts, restorers and researchers.

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