Interview: The digitization of analogue colors is extremely complex – David Pfluger, Giorgio Trumpy, and Martin Weiss in conversation with Simon Spiegel

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“The Digitization of Analogue Colors Is Extremely Complex”

David Pfluger, Giorgio Trumpy, and Martin Weiss
in conversation with Simon Spiegel

The vast diversity of color technologies developed during the course of film history poses a serious challenge when it comes to restoring analogue films. The research project *FilmColors: Bridging the Gap between Technology and Aesthetics*, funded by an Advanced Grant from the European Research Council (ERC) and carried out at the University of Zurich, investigates the interaction between the technological processes and aesthetics of film colors with the aim of improving the digitization and restoration of color films. To this end, the team is also developing a multispectral film scanner.

Giorgio Trumpy, David Pfluger, and Martin Weiss form the technical team of the *FilmColors* project. Trumpy holds a PhD in Scientific Photography and has worked on other color-related research projects in the past. Pfluger, who did his PhD in chemistry, has many years of experience in film postproduction and restoration. Weiss is a cinematographer by training but has worked in the field of digital film restoration for more than ten years.

Simon Spiegel **Simply put, can you briefly summarize the aim of your research?**

Martin Weiss We develop processes to migrate the color of historical films into the digital world.

David Pfluger The standardization of color is extremely complex. This is true for all areas—from painting and printing to film. Our perception is individual, and it is generally hard to define colors in a clear and definite way. Looking at the domain of color film, one has also to be aware of the fact that historically there have been a huge number of different color processes, which work very differently. As a consequence, the digitization of color films is a daunting task.

Giorgio Trumpy The most important part is probably migration. The process of copying in the sense of transferring image information from one carrier to another has always been an essential part of photography and therefore also of cinema—photographic moving images. With the arrival of digital tools, there is much more freedom when it comes to reproduction. But this also poses the risk that the process gets out

of control. One of our aims is to limit potential fallacies and inaccuracies.

S.Sp. **It almost sounds as if the advent of digital technology is a problem rather than an opportunity.**

M.W. I wouldn't call it a problem. Working with digital technology certainly offers new possibilities—which also means new possibilities of doing something wrong. But from the point of view of preservation, the biggest advantage is that once you have a digital element of a film, you can produce as many identical copies as you like, without any loss of image information/quality. This is a new situation we never had with analogue film.

S.Sp. **Film scanners are an established technology. Can you add anything new in this area?**

G.T. When you digitize a film, you always work with a reference image that serves as a guide to how the final image should look. For film restoration, this reference should always be the cinematic presentation on the screen, meaning the projected image as it was originally seen by the audience. The problem is that it is almost impossible to work with a projected moving image during the restoration process. Projectors are bulky machines, they can damage historical films during projection, and you cannot pause a running projector because otherwise the film strip would start to burn.

S.Sp. **Why is it so important to reconstruct the projected image?**

G.T. Because the projected image can differ quite dramatically from the image as it is printed on the film strip. When working with a film, archivists normally use a light panel with scattered light and see the image under diffuse illumination conditions. Film scanners use the same diffuse illumination. In projection, however, it is important to get as much light as possible on the screen. This is why projectors have a light condenser which produces a directed beam toward the screen.

M.W. The resulting geometry of illumination is completely different, and, in some cases, this can lead to striking discrepancies. We have examples where the color of the projected image looks very different from the one on the film strip. Contrast is also affected.

S.Sp. **How do you go about this? Can this effect be added by software after the scanning?**

M.W. No, that's not possible. The so-called Callier effect is an optical phenomenon, which depends on multiple variables and has to be captured during the scanning process.

G.T. Today, all available scanners work with diffuse light. And there are good reasons for this. Diffuse illumination has important advantages when it comes to minimizing dust and scratches, thus not transferring them from the analogue film material to the scanned moving images. That is why we are building a device that allows you to switch between diffuse and condensed illumination. This is a feature not available in any of today's scanners.

D.P. Another important point is that most commercially available scanners were originally geared toward film production. This means they were meant to scan a film negative, and the result was then used in postproduction. The requirements in this case are completely different compared to trying to digitally capture and display a historical film projection. Today's scanners work with three spectral bands Red, Green, and Blue. We, on the other hand, are building a prototype that works with up to twenty-five spectral bands.

S.Sp. **That is more than an eightfold increase in acquired data. Is this really necessary?**

G.T. For the purpose of scientific research, having twenty-five spectral bands makes sense, but for actual use in the archives a much lower number will be sufficient. We are currently running tests to determine the optimum number of bands. But it will certainly be more than the three bands commonly used today.

S.Sp. **Are you actually developing a commercial product?**

G.T. We want to come up with a solution that can be combined with existing hardware. To achieve this, we are cooperating with a scanner manufacturer. But whether this will lead to a commercial solution and how the scanner will look is not under our control. Ultimately, it is quite a leap from a proof of concept to an actual product.

S.Sp. **This scanner already exists as a working prototype. Does this mean that all the problems are basically solved?**

G.T. Our scanner delivers very high-precision data, but this is only raw information which must then be interpreted. To do that properly, you need to know a lot about the film stock that you are working with, about its chemical composition and how it might have originally looked.

D.P. If we look at who restores films today, we come across a fundamental problem in terms of strategy: in the regular production of a new film, color grading is done by a technical specialist under the supervision of the director and/or cinematographer. Together they give the film its final appearance. This is a creative process. Restoring a film,

on the other hand, is not meant to be a creative process. Here, the goal should be to reconstruct the historical look as accurately as possible. But today, the grading of a new film and the restoration of an old film are often done by the same people. So there is an inherent danger that the restoration is treated as a creative act as well and that the color grader will make adjustments according to his or her personal taste. This is, of course, not the proper procedure for restoration. Graders from the field of film production have technical know-how that is absolutely essential for restoring film colors, but they have to perform their work under very different conditions.

S.Sp. **In other words, color restoration is not only a technical challenge but also one of establishing standards and guidelines?**

M.W. Very much so. The idea is to base the process on hard scientific data instead of the more or less educated guess of the person doing the restoration. We have tested our new approach in several case studies, and it works. First, we do our measurements and compare them to the results from a commercial scanner. On the basis of the differences, we calculate a so-called lookup table (LUT), which compensates for the color distortions of the scanner. The actual color grading is then done by means of this LUT. This is a semi-automatic workflow, and we can confidently say that the results are superior to a mere human grading.

S.Sp. **The ultimate goal is a completely automated process?**

D.P. We will probably never reach the point where the process is fully automated and no human intervention is needed. But this is also not our goal. In particular, the accompanying historical research, which contributes to a better understanding of the aesthetics and materials used at the time a specific film was produced, needs human expertise. In this way, we can develop predefined settings based on scientific research data for certain groups of films.

S.Sp. **Your approach is only possible when you know how the color of a film originally looked in projection. How do you reconstruct this?**

G.T. There are different aspects to this. Early dyes used for hand-coloring and tinting are relatively simple, chemically speaking, and quite stable. Later color processes, which aim to accurately reproduce natural colors with an emulsion sensitized to different parts of the visual spectrum, are much more complex. These are proper chemical bombs. But thanks to the research done in the field of photography, we know how they behave over time.

D.P. Sometimes, we do not have access to the original film elements. Nitrate film, for example, is very fragile and cannot be projected anymore due to its flammability. This is the point where the exhaustive aesthetic research of our colleagues from the humanities in the *FilmColors* project comes in. They travel to archives all over the world to photograph samples of historical film materials in high definition with a modular, calibrated camera setup, and they also study how the films from certain periods used to look.

G.T. The photographs form part of the *Timeline of Historical Film Colors*, which was established in 2012 and provides comprehensive information on the evolution of color film technology. Recently, we started including spectroscopic measurements carried out on historical film colors. We are building a spectral database that will help future research on film technology.

M.W. There are limits to what historical research and material analysis can achieve. Ultimately, there will always be a knowledge gap. Our goal is to come as close as possible to the original color appearance as projected on the screen and make the process that got us there transparent.