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Current practices for autochrome digitization

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Abstract

Autochromes, invented by the Lumière Brothers in 1907, consist of a glass plate, photographic emulsion, and a colour filter made of dyed potato starch granules and carbon. Due to the autochrome's fragile nature and susceptibility to fading and damage, many institutions limit the plates' exposure to light and movement. This highlights the importance of high-quality digitisation to ensure wider public access and preservation. Currently, there are no specific guidelines for digitising autochromes. To address this, a survey was conducted to understand current practices around autochrome digitisation. Additionally, imaging tests were performed to evaluate different methods and provide guidelines. The survey results and experimental findings will inform standardised digitisation approaches.

Introduction

Autochromes, the invention of the Lumière Brothers, were released commercially in 1907 and comprise a glass plate, photographic emulsion, and a colour filter made of miniscule potato starch granules dyed red, green and blue. The glass basis of the plate, and the fugitive nature of dyes in the colour filter, make autochromes prone to breakage or changing via issues like 'greening', where green dyes bleed across the plate, often because of exposure to moisture. Furthermore, autochromes are highly prone to fading as the dyes are extremely light sensitive [1].

For these reasons, many museums, galleries and heritage organisations holding autochromes have elected to limit plates' exposure to light and movement via banning exhibition, restricting public access and only allowing for plates to be viewed under strict circumstances, which includes observing plates for short periods of time on light boxes set to low lux levels, situated within dark spaces [2]. These circumstances underline the significance of digitising autochromes to a high standard to enable wider public access and the production of facsimiles in place of original plates. This ensures that audiences are still able to appreciate and view this significant early colour photographic process.

However, to date, there are no specific published guidelines around the digitisation of autochromes. Due to the very low transmittance of autochromes, traditional or standard imaging workflows such as FADGI [3], ISO/TS 19264-2, and then Dutch National Archive [4] that include recommendations for translucent materials, do not fully address the subtle needs of autochromes. This unique challenge necessitates the development of specialised techniques tailored to the specific properties of autochromes. Bertrand Lavédrine and Jean-Paul Gandolfo's seminal text The Lumière Autochrome [5] provides a succinct overview based on the digitisation of the Albert Kahn autochrome collection. Advances in technology since the book's publication will have a corresponding impact on digitisation procedures. Furthermore, the guidelines need to be straightforward and accessible to a broad audience, ensuring they can be easily understood and implemented even by smaller institutions with limited resources or technical capacity that rely heavily on volunteers. These needs have inspired the following project, focusing on the necessity of developing accessible guidelines regarding the digitisation of autochrome plates.

To gauge current autochrome digitization practices, a survey was devised. The questions considered the imaging equipment used, workflow patterns, lighting systems and processing equipment, and the use of post-processing. The survey was sent to museums, galleries and heritage organisations holding autochromes, such as the Victoria and Albert Museum, the Preus Museum and the Royal Photographic Society (United Kingdom).

The survey results will inform on the state of the field, while pointing out areas that could see a more standardised or improved approach. During this ongoing project, it has become apparent that two issues are particularly prevalent: whether to expose for the backlight or the autochrome highlights, and whether to cover the backlighting source around the autochrome plate. For more mainstream translucent heritage materials such as chromogenic film, these steps are well defined. It is generally safe to assume that the brightest part of the film is almost transparent, allowing the exposure to be set to that of the lightbox and used for all negatives. However, autochromes are optically dense, meaning even the brightest point on an autochrome is much darker than the white of the lightbox. To determine the optimal exposure settings and the effect of covering the backlighting source, imaging tests were conducted, and the image quality of the results was compared.

Methodology

A comprehensive survey was conducted to gather detailed insights into the current digitisation practices for autochromes. This survey was meticulously crafted by a team of imaging experts and an autochrome researcher, ensuring that it addressed specific issues related to the imaging workflow of autochromes. The survey included questions designed to elicit detailed responses about the various techniques and challenges faced by institutions in digitising autochromes. Administered using Airtable, the survey allowed for efficient data collection and organisation. Once the data was collected, it underwent thorough analysis to extract meaningful insights, which will contribute to understanding and improving digitisation practices for autochromes. Based on the findings of the survey, a series of imaging tests were conducted to compare different methods and workflows.

Participants

To gather comprehensive data on current practices for autochrome digitisation, a carefully designed survey was distributed to a diverse range of museums and cultural heritage institutions known to hold autochromes in their collections. The survey was disseminated through multiple channels to maximize reach and engagement, including newsletters, mailing lists, social media platforms, presentations and workshops, as well as direct contact. This multi-faceted approach ensured that the survey reached a broad audience within the targeted community.

A total of 15 institutions responded to the survey, providing a valuable cross-section of insights. The participants, who are directly responsible for the digitisation of autochromes within their respective collections, shared detailed information about their current methodologies and practices. The survey was meticulously crafted to address the specific needs and challenges of this niche audience, ensuring that the responses were highly relevant and focused on the topic at hand. This targeted approach allowed for the collection of nuanced data that will contribute to a deeper understanding of autochrome digitisation practices across different institutions.

Survey structure and data collection

The survey comprised eight distinct parts, featuring a mixture of yes or no questions and open-end questions to allow for detailed clarification. It was designed to be straightforward, employing technical language only when necessary to ensure clarity and accessibility for all respondents. The questions were as follows:

1. Questions about the autochrome collection:
   - Collection name
   - Number of autochromes in collection
   - Date of digitisation
2. Questions about the equipment used:
   - What imaging equipment was used?
   - What backlighting system was used?
3. Questions about the backlight, specifically if a lightbox was used:
   - If using a lightbox, was the lightbox surface around the autochrome covered?
   - If yes, how was this done?
4. It is common to find autochromes with information on the borders which needs front lighting to image correctly. If relevant, questions about the use of a front lighting system:
   - To make inscriptions, stickers and other markings on the plate borders visible, a light source positioned above the plate (front light) is sometimes used. Was a front lighting system also used?
   - If two images were captured (one front lit, the other back lit), what was the procedure to merge the two images?
5. Exposure settings questions:
   - What was the procedure to determine the right exposure settings? What is the software used to determine it?
   - Were the exposure settings adjusted plate by plate or were they fixed for a batch of plates?
6. File format questions:
   - Are the images acquired in raw format?
   - If yes, what software and what options are used to convert the raw files?
7. Processing workflow questions:
   - What processing workflow was used for the captured images? (This includes white balance, exposure/histogram manipulation, colour management, curves, for instance.)
8. Further information and participant's personal information.
   - Is there any further information you would like to add regarding the digitisation of autochromes?
   - The investigation would greatly benefit from receiving a raw file. If you are happy to send a file, could you please email to [author's email]
   - Your name
   - Your contact

Imaging set-up

Imaging tests were performed to evaluate the effect of different imaging pipelines on image quality. To this purpose, basic autochrome digitization setup was designed, composed of a digital camera and a lightbox (see Fig. 1). An autochrome acquired for research purposes was used for these tests.

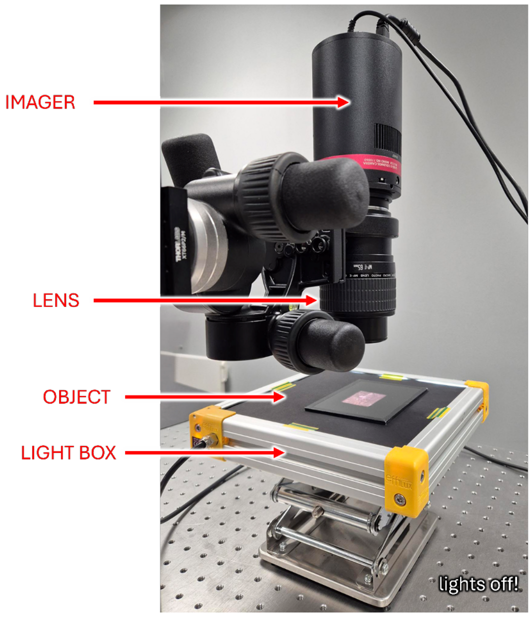

Figure 1. *Imaging setup for autochrome digitisation.*

Survey findings

Survey participants provided detailed responses on the nature of their autochrome collections and their imaging workflows for digitisation. There is no overall consensus or standardised workflow for digitising autochromes, highlighting the diversity of practices across institutions. The main issues identified were determining the correct exposure settings and deciding whether to cover the light source around the autochrome. The following subsections summarise the survey findings.

Autochrome collections

The survey results show a diverse range of autochrome collection sizes. Responses varied significantly, with some collections containing as few as 6 autochromes, while others reported having up to 15,000. Several collections had intermediate sizes, such as 100, 224, and 2,500 autochromes. This variety highlights the broad spectrum of collection sizes among respondents, reflecting both small and extensive collections, as well as the relative rarity of autochromes.

The digitisation dates also varied widely, ranging from as early as 2003 to as recently as 2024. Some collections were digitised over multiple years. Additionally, some respondents mentioned various dates, with some autochromes scanned at least 20 years ago, and noted that their collections have grown over time. The most recent digitisation efforts were reported between 2019 and 2024. These varied dates imply that the digitisation of autochrome collections is an ongoing and evolving process.

Equipment used

The survey results indicate the use of a variety of imaging equipment brands for digitising autochrome collections. The most frequently mentioned brand was Phase One, appearing 10 times. Canon was mentioned 4 times, while Sony appeared 3 times. Nikon was mentioned twice. This distribution highlights the preference for high-end, professional-grade equipment among respondents, with Phase One being a particularly popular choice for digitisation efforts.

Respondents predominantly used lightboxes for their digitisation efforts. Among these, some specified using LED lightboxes, while others mentioned fluorescent lightboxes. Additionally, one respondent reported using flash lighting. This variety in lighting systems reflects the different approaches and preferences in achieving optimal illumination for digitising autochrome collections.

Covering the backlight

Often, the backlit area around the autochrome is left uncovered (Fig. 2), which increases the total signal of light reaching the autochrome, including stray light that affects image quality. Respondents who do cover the lightbox use a variety of methods, such as adjustable masks, black card strips, and black cardboard to minimize light flare and prevent extraneous light from entering the camera lens. Some used 3D-printed masks or card L-masks for larger sizes, while others employed black matte foam with a window cut slightly larger than the camera's field of view.

Additional methods included using loose strips of card, plastazone enclosures, and heavyweight black paper in a four-bladed easel style. Some collections had frames or were mounted in large mattboards, making additional covering unnecessary. One respondent mentioned using a Phase One capture stage with various holders and 'gates' to elevate the collection item above the lightbox and minimize light leaks. These diverse approaches reflect the different techniques employed to achieve optimal lighting conditions for digitising autochrome collections.

Exposure settings

The survey results indicate a variety of procedures used to determine the right exposure settings for digitising autochrome collections. Some respondents rely on light meters and adjust settings based on the density and transparency of the autochromes. Others set a ground level starting point by adjusting the light panel to 8-bit and then increasing flash power based on histogram readings and measurements of shadows and highlights.

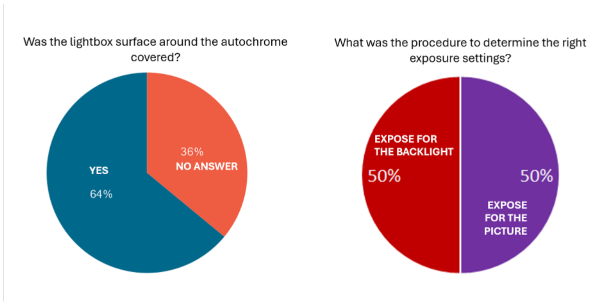

Figure 2. *Distribution of answers for two key questions in the survey. When it comes to the maximum exposure settings, the procedure is evenly divided between using the lightbox as a target and the brightest region in the autochrome. The majority of respondents do not cover the lightbox area around the autochrome plate.*

A common approach involves a transmissive workflow, which includes evening the exposure and white balance of the lightbox with flat field correction, setting optimal sharpness and tonal range, and adjusting exposure time to ensure the lightbox is clipping but not the data in the object. This method ensures the maximum tonal range is captured.

Visual inspection and tests, including the use of grey scales and colour swatches, are also employed. Some respondents use Capture One software for tethered shooting and exposure adjustments, while others rely on direct capture of the light source, setting the light to read at 98L* using CaptureOne colour readouts. Trial and error, exposure bracketing, and the use of tools like the Stouffer 21 Step Transparent Calibration tool are also mentioned.

Additionally, some respondents use black velvet to cover the tripod and camera body to prevent reflections, and others validate settings using software like GoldenThread NXT. The use of IT8 targets and monitoring histograms in Capture One are also common practices. These varied procedures reflect the different techniques and tools employed to achieve optimal exposure settings for digitising autochrome collections.

The survey results also highlight a lack of consensus among respondents regarding whether to expose to the light source or to the autochrome white (Fig. 2). Some respondents prefer to set exposure based on a direct capture of the light source, ensuring the light reads at a specific value, such as 98L*, to achieve uniform sharpness and tonal range. Others adjust exposure to balance the transmitted light with the reflective light, focusing on the autochrome itself to retain detail and avoid clipping. This divergence in approaches underscores the varied methodologies and preferences in achieving optimal exposure settings for digitising autochrome collections.

Several respondents mentioned employing both methods: fixed settings for general consistency and individual adjustments for specific plates to enhance underexposed images and bring out more information. This dual approach balances efficiency with the need for precision in capturing the unique characteristics of each autochrome. The varied responses highlight the lack of consensus among respondents regarding whether to use fixed exposure settings for a batch of plates or to adjust settings for each plate individually. This divergence underscores the different methodologies and preferences in achieving optimal exposure settings for digitising autochrome collections.

Digital manipulation

The survey results reveal a range of digital manipulation techniques used during the digitisation of autochrome collections. Many respondents use Capture One Pro for image capture and colour calibration, with some focusing on metadata injection and cropping, while others blend multiple exposures to capture the full tonal range. Minor adjustments to levels and contrast are common, and some images are enhanced for legibility based on curator directions.

Capture One software is widely used, with efforts to minimize manipulation for archival master files. Autochromes are sometimes captured in multiple tiles and stitched together, with tonal adjustments made to improve legibility. Techniques include setting white balance, exposure/histogram manipulation, and using custom ICC profiles. Basic adjustments like white balance, exposure, and curves are also employed to extract detail while preserving colours.

Some respondents differentiate between 'record' images and 'delivery' images in their digitisation process. For instance, if a series of autochromes are underexposed but still readable, two survey participants save the dark digital images "as-is" to accurately represent the object's current state. These unaltered images serve as archival records, preserving the original condition of the autochromes. Additionally, they create lightened versions of the same images for user copies, enhancing visibility and readability for practical use. This approach ensures both the preservation of the original state and the accessibility of the images for users.

Image quality experiments

The following section will present the results obtained for a series of imaging tests. These experiments aimed to evaluate the signal-to-noise ratio and overall image quality under two different conditions: exposing for the backlight or the autochrome white - and the impact of covering the light around the plate.

Exposing for the backlight vs. exposing for the autochrome

The autochrome was digitised using two different exposure times: 300 ms for the white of the autochrome and 25 ms for the backlight. Consequently, a look-up table (LUT) was applied to the linear image taken for the backlight to achieve compensated exposure. A gamma curve of 1.8 was applied to visualise both images on a display.

Figure 3 shows the results on a zoomed-in section of the autochrome. The left image is the image exposed for the backlight (exposure time: 25 ms). The middle image is the exposure-compensated image (exposure time: 25 ms). The right image is the image exposed for the autochrome (exposure time: 300 ms).

These results show a small yet visible variation (for better results see on a display) between the exposure-compensated image exposed for the backlight and the image exposed for the autochrome. However, the image content of the autochrome is inherently noisy due to the dye layer and the silver grain, making it

Figure 3. *Zoomed-in section of the autochrome. Left: Image exposed for the backlight (exposure time: 25 ms). Middle: Exposure-compensated image (exposure time: 25 ms). Right: Image exposed for the autochrome (exposure time: 300 ms.)*

challenging to discern differences between the two images.

To emphasize the effect of the LUT on the image exposed for the backlight, the camera lens was removed and the sensor was exposed to adjusted ambient light for 25 ms and 300 ms, obtaining flat images with average values similar to those of Figure 3. The flat image at the shorter exposure time had the same LUT applied (left), and the results are shown in Figure 4, compared to the flat image at 300 ms (right). Both flat images had their histogram stretched to a maximum value of 100 for better visualisation.

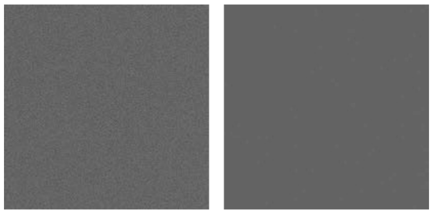

Figure 4. *Noise on dark image. Left: Exposure-compensated image (exposure time: 25 ms). Right: Image exposed for the autochrome (exposure time: 300 ms.) (Histogram stretch to maximum value = 100)*

Here, the effect of the noise is much more visible. The standard deviation of the pixel values of both images was taken as a measure of the noise level. The standard deviation in the image exposed for the autochrome is 5.16, while the standard deviation in the compensated image exposed for the backlight is 30.84, indicating six times more noise.

Covering the lightbox vs. not covering

In Figure 5, the impact of covering the lightbox on image quality can be visually assessed. When the lightbox is covered, image contrast is enhanced, and haziness is reduced. This is because only the light transmitted through the autochrome plate is captured, eliminating stray light that can cause reflections and reduce image contrast.

Conversely, when the lightbox is not covered, a white halo appears over the image due to stray light being reflected on the autochrome plate. This stray light diminishes the overall image quality by introducing haze and reducing contrast. Covering the lightbox ensures that the captured image is free from these unwanted reflections, resulting in improved colour accuracy and greater contrast in the image content.

The colour gamut of both images was plotted using Matlab's Image Processing Toolbox's function *colorcloud* (Fig. 6). The gamut of the image taken not covering the lightbox (on the left) is significantly smaller than the gamut of the image taken covering

Figure 5. The difference between not covering the lightbox surface around the autochrome plate (left) and covering it with a fully-absorbing black sheet (right) is obvious with the naked eye in terms of image contrast.

the lightbox (right). The known effects of a larger gamut on image quality broader colour range, which results in better contrast and details, as more subtle variations in colour are visible. A larger colour gamut also increases colour accuracy. These effects are all visible in Figure 5. These results highlight the importance of covering the lightbox around the autochrome to achieve optimal digitisation results for autochrome collections.

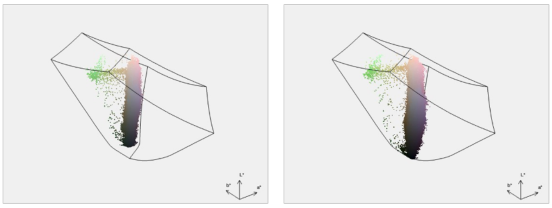

Figure 6. Colour gamut of the image taken not covering the lightbox (left) and covering the lightbox (right).

Conclusion

A survey was conducted to gather information on the digitisation of autochromes, covering various aspects such as the size of autochrome collections, the equipment used, the methods for determining exposure settings, and the digital manipulation techniques employed. Participants provided detailed responses, offering insights into their diverse practices and workflows.

The survey revealed that there is no consensus on the best practices for digitising autochromes. Two main issues were identified that significantly affect the final image quality: whether the exposure should be set to the lightbox or to the autochrome white point, and whether the light around the autochrome should be covered or not. These factors contribute to the variability in digitisation outcomes.

Image quality experiments were conducted, showing that the signal-to-noise ratio is six times higher when the exposure is set to the lightbox compared to the autochrome white point. Additionally, it was found that not covering the lightbox around the autochrome increases haziness and decreases contrast, further impacting image quality.

Future work will involve using the survey results to draft imaging guidelines specifically for autochromes. These guidelines will address the two main issues identified and aim to provide straightforward and practical instructions that can be followed by professionals in the field, even with basic equipment. The goal is to establish more consistent, standardised digitisation practices and improve the overall quality and consistency of digitised autochrome images.

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