Alternative Photographic Processes Reimagined: The Role of Digital Technology in Revitalizing Classic Printing Techniques

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ABSTRACT

The transition from film to digital has influenced photography techniques, with implications for both cultural and technical aspects. By examining the history and concepts of classical photography and incorporating computer intervention in revitalizing alternative photographic processes, we aim to expand aesthetic expressions in art, computer graphics, and our understanding of photography's cultural significance. Integrating computer processing with techniques such as salt print, platinum print, and cyanotype, this study seeks to create a new photographic experience that embraces the joy of materializing scenery and highlights the interconnectedness of technology and art.

CCS CONCEPTS

• **Applied computing → Media arts**; • **Human-centered computing → Visualization toolkits**.

KEYWORDS

Alternative Photographic Processes, Cyanotype, Platinum Print, Salt Print, Data-driven Simulation, Optimization

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1 INTRODUCTION

It has been 180 years since Niepce invented photography, and photography, once a frontier that led to the co-evolution of chemistry, optics, and art, has now moved to the intersection of computing and art. The number of digital camera units shipped each year is now in the billions, with about 10,000 cameras shipped each year compared to the 1980s when film cameras were at their peak [HOSOYA and TANIGUCHI 2019]. Of course, it may be difficult to claim that cameras such as surveillance cameras and smartphone multi-eye cameras are necessary for artistic purposes. However, there are more cameras on the planet than there are eyes on all living people, and they have become such a widespread commodity on the planet that they can be considered one of the new environmental resources [Turner 2023]. When you eat, when you spend an important page of your life with friends, when you check the growth of your pets or children, and not only in such essential life events, but also in all your networked communication, you are always communicating visually. As we are constantly surrounded by images in our daily lives, it is important to consider the role of photography in both popular culture and art. So, what about photographs as works of art with physical forms? This refers to an analogue print that can be framed and displayed in a room. About such analogue prints, we have previously conducted research on a new printing method that integrates computer processing with full-color printing of cyanotype [Ozawa et al. 2022]. Based on this research, we have also considered how computational processing can be integrated into other printing methods, such as salt and platinum prints, and how the use of different materials that were not considered at the time can expand the expressive power of these printing methods. In this way, our case studies on alternative process are inspired by exploring both the artistic and technological aspects of computer graphics research has done [Wilder 2009]. The computer graphics community has driven this digital world as the driving force of current photo editing and visual communication. Now that photographic images can be obtained without a camera through generative AI prompts [Iyenger 2020], and stock photos are being proposed [Barnard 2017], communication through photographs is changing radically. When considering the continuation and development of the tradition of the viewing space of classical photographs and the preservation of exhibition spaces, one of the things that the media art and graphics community should address is the exploration of materialized photographic alternatives [Kelsey 2015]. We believe that this alternative process should be considered with factors such as current environmental issues and difficulties in obtaining film, but also with the advantages of abundant computer resources.

Contributions. In this paper, we highlight our contributions to the field of alternative photographic processes from both technical and cultural perspectives. Technically, we present a novel tone adjustment method that enhances image processing and optimization, enabling the creation of precise digital negatives. Culturally, we explore the historical and artistic context of these processes, enriching the understanding of photographic art and paving the

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way for future innovation. Combined, our contributions bridge the gap between traditional and digital techniques, fostering cultural enrichment and broadening creative possibilities.

2 ORIGINS AND EVOLUTION OF PHOTOGRAPHY AND CAMERAS

2.1 The Origins of Alternative Processes

Alternative processes are photographic printing methods that involve exposing a negative onto a material using photosensitive chemicals (Figure1). These processes have deep roots in the history of photography, representing early experiments in capturing images through chemical reactions and light. The development of alternative processes, key historical works, and recent resurgence in interest are all part of this ever-evolving field. The origins of alternative processes go back to the 19th century (Figure2), with the daguerreotype as the first successful method [Barger and White 2000]. It used a silver-plated copper sheet exposed to iodine vapor, but was cumbersome, leading to a search for practical processes. The calotype emerged in the 1840s, using a light-sensitive paper negative, allowing multiple prints from a single negative [Greene 2013], and inspiring future techniques like the salt print and albumen print. Throughout the 19th century, photography enthusiasts continued to develop a variety of innovative alternative processes, some of which remain popular and relevant today. Some of the most significant processes and their associated works include:

- **Salt print:**One of the earliest photographic processes, the salt print was created by using a mixture of table salt and silver nitrate to form a photosensitive layer on paper [Anderson 2017]. The process was popularized by Henry Fox Talbot and was used for his famous work, "The Haystack" (circa 1844).
- **Cyanotype:**Developed by English scientist Sir John Herschel in the 1840s. One of the most famous examples of cyanotype photography is Anna Atkins' "Photographs of British Algae: Cyanotype Impressions" (1843), which is considered the first book of photographs [Ware 2014].
- **Platinum print:**Invented in the 1870s by English chemist William Willis, platinum prints are characterized by their rich tonality, long-lasting image stability, and luxurious appearance. Well-known photographers such as Edward S. Curtis and Alfred Stieglitz embraced platinum prints for their artistic expression. Stieglitz's photograph "The Steerage" (1907) is an excellent example of the process [Ware 2017].

2.2 Timeline of Photographic and Camera Evolution

Looking back at the history of photography, its origins can be traced to very simple imaging devices like the camera obscura. This primitive method involved creating a small hole in one corner of a room to project the external scenery or objects onto the room's wall. However, this technique underwent a revolutionary progression, evolving into what is known as the daguerreotype. This marked the first-ever technique capable of capturing and preserving instantaneous images on a physical medium. Following the era of alternative processes, the age of film cameras dawned. With the use of film, it became possible to capture and store a greater number of photographs. Then, by the end of the 20th century, digital cameras emerged, introducing a new revolution where photographs could be stored in electronic formats, making editing and sharing much more convenient. In essence, the technological journey of photography and cameras has traversed four significant transitions: from the camera obscura to alternative processes, then to film cameras, and finally to digital cameras. In the next chapter, we will delve deeper into how these physical image-preserving techniques merged and evolved with computational technology.

3 INTEGRATION OF COMPUTERS AND PHOTOGRAPHY

Photography, an art of capturing moments through light, is intrinsically tied to science. Traditionally, images were projected onto photosensitive surfaces, then recorded and printed. This record-and-print methodology underpinned photographic technology until the digital era. As photography evolved, it embraced technology in two primary ways. The first is the integration of computational technology, broadening what's achievable through computerized enhancements. The second is the incorporation of digital technology, blending traditional methods with modern digital approaches. We introduce the "Computational Alternative Photographic Process," a method that synergizes these two technological advancements, paving the way for a holistic approach to contemporary photography.

3.1 Latest Digital Photographic Techniques

With the integration of computational technology, it has become possible to control visual data precisely as one desires. The advent of digital photography can be traced back to the 1980s when techniques to convert images into electrical signals for recording were developed. This digitization shifted our photo viewing habits. Instead of traditional methods like film and prints, we now use devices like monitors. This change in photographic appreciation has had significant impacts on both society and the arts. The rapid advancement in imaging technology has enabled the development of techniques that meet societal needs. For instance, technologies such as HDR image, panoramic photography, and computational photography have emerged. Due to these new technologies, parameters like brightness, contrast, and depth in photographs can now be adjusted freely both before and after taking a shot.

3.2 Updating Traditional Methods with Digital Technology

Through the integration of digital technology, we've made strides in refining the photographic experience, putting control directly into the hands of users. As photography evolved into its digital form, digital cameras naturally became the primary means of capturing images. In our modern era, even devices not originally intended for photography, such as personal computers and smartphones, frequently feature built-in cameras. Meanwhile, traditional photographic devices, such as large-format and film cameras, continue to find relevance. Despite a decline in their popularity, a passionate community still values and uses them. An emerging approach

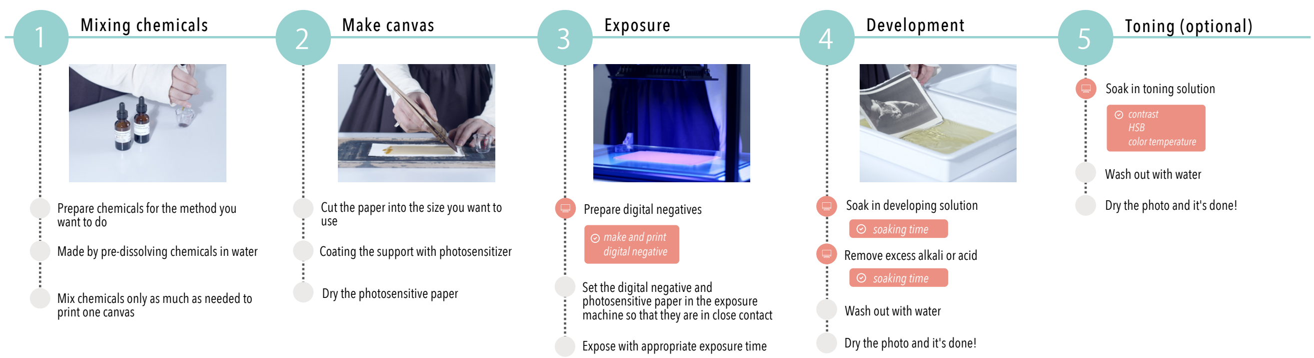

Figure 1: The diagram illustrates a four-step method for the development of alternative photographic processes, including selecting a light-sensitive material, preparing it, coating it onto a substrate, exposing it to light, and developing and fixing the image. This method is a systematic approach to developing alternative photographic processes.

involves updating these classic cameras with contemporary technology, providing them with a new lease on life. Some remarkable efforts in this direction include the Intrepid Camera[1], Cameradactyl[2], and I'm Back[3] (Figure3). Interestingly, when users have a hand in shaping the tools they use, it greatly improves the user-friendliness and overall experience of photography. In summation, these collective endeavors and scholarly pursuits underscore the expansive potential emerging from the nexus of computational technology and age-old photographic techniques, indicating promising avenues for future research.

3.3 Application of Computational and Digital Techniques to Traditional

Combining digital and computational technologies creates a new context in photographic culture. In the history of photography, merging digital photography with old photographic tools expanded people's vision and improved the photographic experience. We believe collaborating with the "Alternative Photographic Process" can enhance these effects. With digital technology, we can print the negatives used in the Alternative Process with standard printers. This allows digital photos to be printed in traditional ways without actual negatives. With computational technology, we provide a user interface for image editing and optimization for the alternative photographic process. This means no need for chemical adjustments, and users can preview before printing. These two trends in the alternative photographic process printing framework symbolize the next phase in photographic technology. Furthermore, new photographic tools resulting from this trend make it easier to reflect users' creativity in photos, marking a significant artistic advancement.

[1]https://intrepidcamera.co.uk/
[2]https://www.cameradactyl.com/
[3]https://imback.eu/home/

4 OUR DIGITALLY INTEGRATED ALTERNATIVE PHOTOGRAPHIC PRINTING FRAMEWORK

Based on Section 3, we constructed a contemporary alternative process printing framework by integrating digital and computational technologies with the alternative process. Furthermore, we developed a computer system to generate positive images suitable for digital negatives, specifically tailored for our printing framework. This computer system includes features for image editing, optimization, and post-printing color simulation (Figure4). The code and demo can be found at https://github.com/DigitalNatureGroup/computational-alternative-photographic-process.

4.1 Application for Tri-color Cyanotype

Traditional cyanotype photography was limited in its color range, primarily restricted to shades of blue, leading to a narrow printable color spectrum. To address this limitation, the tri-color cyanotype was developed [Golaz 2021]. This technique involves layering cyanotypes in three distinct colors—cyan, magenta, and yellow—producing photographs with a rich and varied palette. While this method revolutionizes the color range attainable with classic cyanotypes, it prolongs the time needed for printing a single sheet and introduces complexity to the development process. We developed a computer system to generate positive images suitable for digital negatives [Wilder 2009]. The key features of this approach include:

- Real-time previewing of the printed outcome through data-driven simulation.
- GUI-supported parameter adjustments on the reference image.
- The creation of negatives for improved post-print contrast, achieved through optimization targeting the original image.

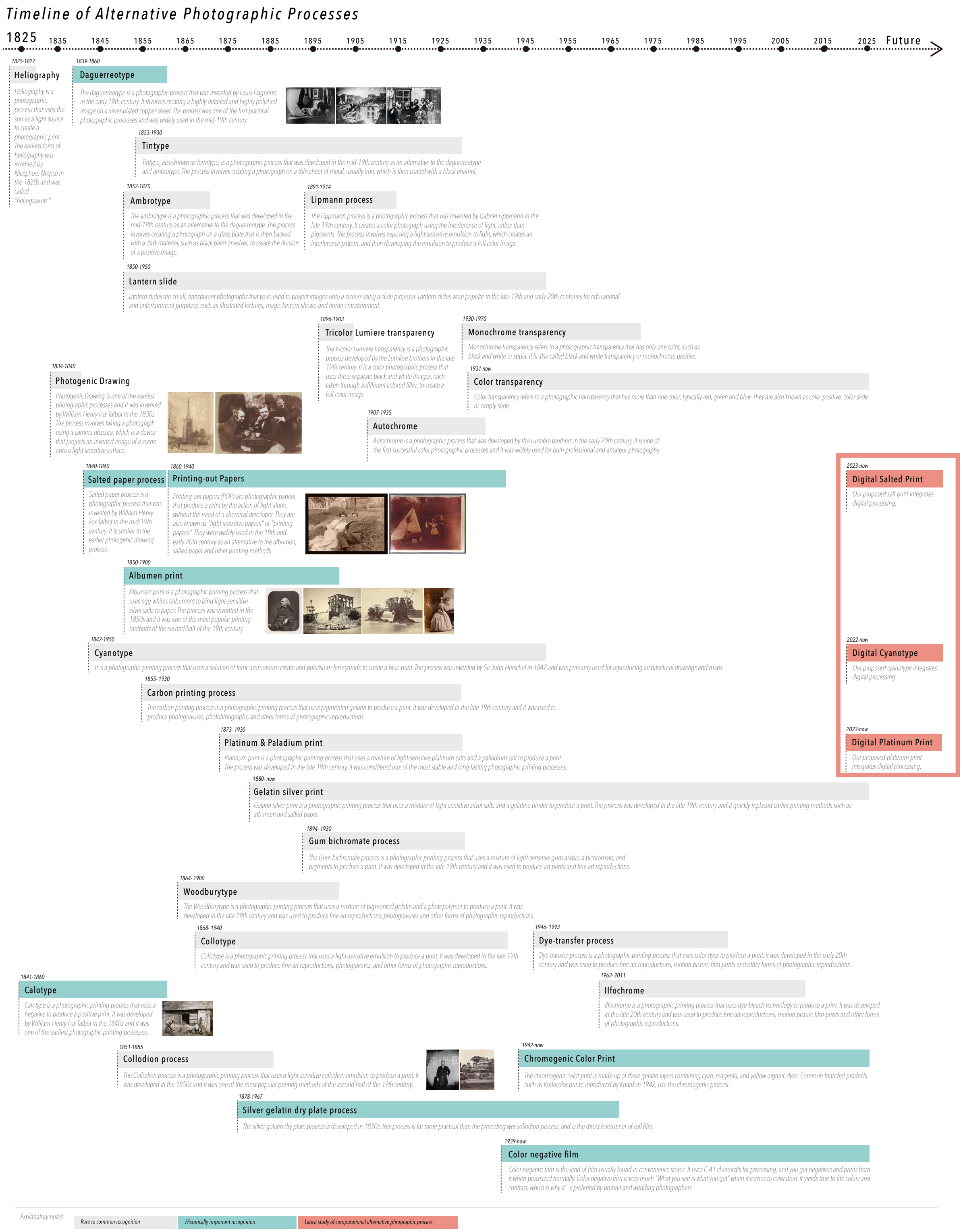

Figure 2: The timeline illustrates the evolution of alternative photographic processes from the early 19th century to the present day, starting with the invention of Photogenic Drawing by William Henry Fox Talbot in 1839. It charts the development of various techniques such as the Salted Paper process, Cyanotype, Albumen print, and Collodion process, along with their approximate date of invention and notable characteristics. The timeline highlights the significant contributions made by photographers, scientists, and inventors in the field of alternative photographic processes and the impact they have had on photography.

Figure 3: Examples of updating traditional methods with digital technology. (a) Intrepid Camera[1], a large-format camera utilizing 3D printing and eco-friendly materials. (b) Cameradactyl[2], a large-format camera with a body manufactured using 3D printing. (c) "I'm Back"[3] gadget, allowing the attachment of digital sensors to film cameras. These images were taken from the sites mentioned in the footnote.

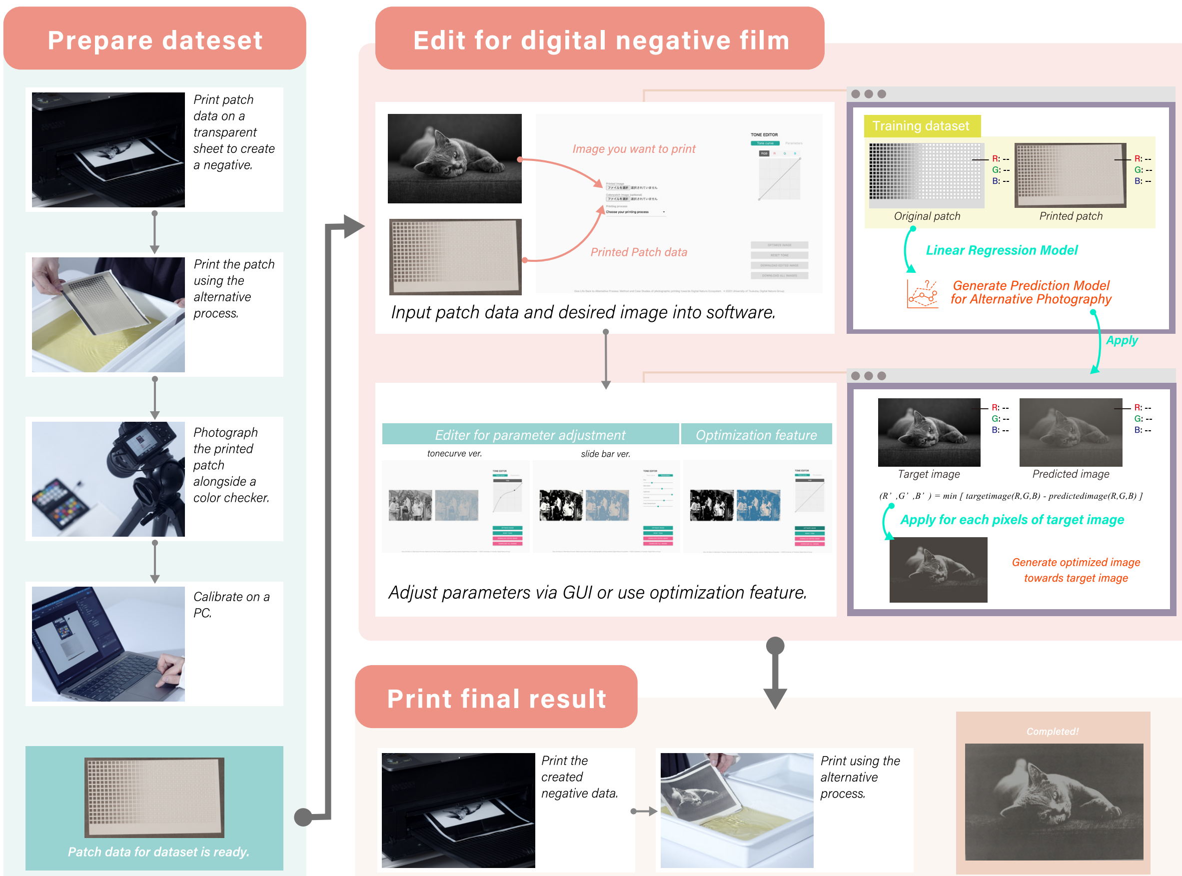

Figure 4: System diagram for alternative photography printing framework.

4.2 Application for Monochrome Alternative Photography

Building on our multi-color cyanotype approach introduced in section 4.1, we further explored the potential of emphasizing the inherent monochromatic characteristics found in alternative photographic processes. We've updated our software to cater to monochromatic printing by adapting the methods from section 4.1[Ozawa et al. 2023]. The following novel features were incorporated:

- Users can now select their preferred printing method before initiating the print.
- For parameter adjustments, in addition to the intuitive GUI, a tone curve tool has been made available.

- An image optimization feature tailored for monochrome printing has been introduced.

4.3 Digital Tools

We developed software for the alternative photographic process. This software comes with a user interface and primarily offers three main functions: post-printing color simulation for the alternative photographic process, image editing, and image optimization.

4.3.1 UI. Our developed software is accessible to anyone from the web and can be used without the need for downloads. The printing procedure using this system is as follows: First, we print patch images using the alternative process. The printed color patches are then photographed alongside the color checker with a camera and calibrated on a PC. Users upload this data, along with the image you wish to print, to the system. Subsequently, you can edit the image using sliders and tone curves, or optimize it, and then download the positive image for creating a digital negative. Using this image, you produce a digital negative with a printer, which is then printed using the alternative process. Color tone editing of images is done using tone curves as shown in Figure 5(a) and sliders as depicted in Figure 5(b). By integrating the above components, our system offers an intuitive platform for users to craft specialized negatives. The seamless interactivity ensures that adjustments to the post-print photograph are achievable without delving into chemical or material parameter modifications.

4.3.2 Prediction model. The prediction model is designed to simulate the printing results of the alternative process. Specifically, the system utilizes a dataset of specific color patches to predict the color after the alternative process.

Preparing the patch. Initially, color patches corresponding to pixel values from 0 to 255 are printed using the alternative process. These printed patches are photographed with the x-rite's ColorChecker, and color calibration is performed using the ColorChecker Camera Calibration[4]. The calibrated RGB values, paired with the original color information, compose the dataset.

Training the model. The gathered training data is then employed with a linear regression model to construct the prediction model. This model, when given new color information, predicts the color post the alternative process. The predicted color value $\hat{c}$ can be determined using the equation:

$$\hat{c} = w_0 + w_1 r, \tag{1}$$

where r represents the grayscale value of the image, and w_1 denotes the coefficient for color value prediction. For a linear regression model, the coefficient w_1 must be optimized. The optimal coefficients w^* are derived by solving the following optimization problem:

$$\mathbf{w}^* = \arg\min_{\mathbf{w}} \|\mathbf{X}\mathbf{w} - \hat{\mathbf{c}}\|_2^2, \tag{2}$$

where X represents the original patch values, $\hat{c}$ are the measured patch values, and w are the coefficients for color value prediction. This predictive model was developed using the linear regression model provided in scikit-learn[6].

4.3.3 Optimization towards target image. While users can edit images via our UI, we also offer an image optimization feature to make achieving the best printing results more straightforward. In this optimization process, we aimed to get the printing result as close to the target image as possible within the printable color gamut of each alternative process.

Retrieving Image Color Information. The RGB values of each pixel are extracted from the provided input image.

Predicting the Color. Using the predictive model, the system predicts the color of each pixel based on patch printed by alternative photographic process.

Calculating the Loss. The difference between the predicted colors and the original colors is computed, with the smallest difference signifying the most accurate replication. To derive the optimal input values c^* for the negative used in the actual printing process, the following optimization problem was solved:

$$\mathbf{c}^* = \arg\min_{\mathbf{c}} \left\|\hat{\mathbf{c}}(\mathbf{r}, \mathbf{g}, \mathbf{b}) - \mathbf{c}_{\mathrm{img}}\right\|_2^2, \tag{3}$$

where c denotes the RGB values of the image in each iteration and c_{img} represents the RGB values of the target image. The optimization process was conducted using TensorFlow[7], employing Adam for optimization.

Adjusting Color Information. Based on the computed loss, the original RGB values are adjusted. This adjustment is iteratively applied to each pixel of the image. Ultimately, the image obtained from this optimization process will most accurately replicate the results after the alternative process.

5 CASE STUDY AND RESULTS

We present results for our framework tailored for tri-color Cyanotype. Figure 6(a) demonstrates that our design can adapt to various images and patches, enabling diverse three-color prints. Figure 6(b) displays our color prediction based on patch measurement data. While the actual print isn't perfect, especially in the blue shades, it largely aligns with our predictions. The optimization further refines the outcome, enhancing the contrast in the final image.

In this case study, we will be exploring the use of computational processing to adjust tones in three different types of prints: cyanotype, platinum print, and salt print. These alternative printing processes have a rich history and offer unique aesthetic qualities that set them apart from traditional photography. By using computational processing to adjust tones, we can expand the range of expression and create distinct and visually striking images. The results of this case study will be useful for photographers and artists looking to explore new possibilities in their work and for anyone interested in the potential of computational processing in the field of alternative printing. In our system, we use prediction and optimization as core technologies to perform tonal adjustment printing.

[4]https://calibrite.com/us/software-downloads/

[6]https://scikit-learn.org/stable/modules/generated/sklearn.linear_model.LinearRegression.html

[7]https://www.tensorflow.org/

[4]https://p5js.org

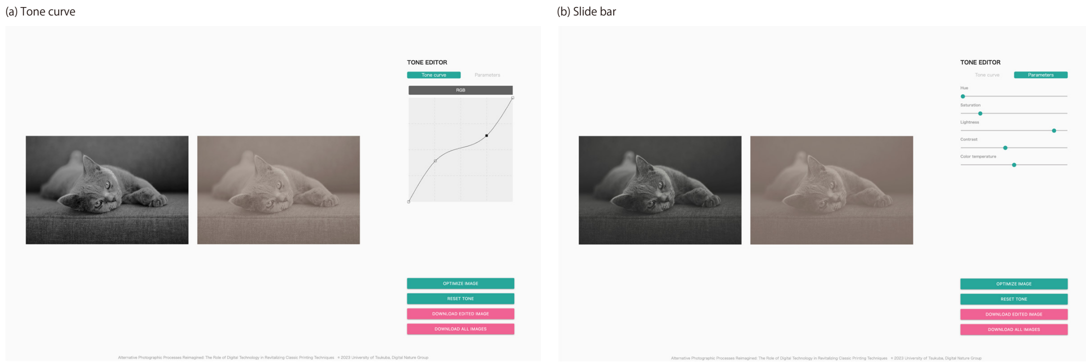

Figure 5: The UI of the software based p5.js [4] we developed. (a) Shows the screen where images are edited using a tone curve. (b) Displays the screen where images are adjusted using sliders

Figure 6: Results of printing the Tri-color cyanotype using the printing framework we constructed. (a) Examples of prints accommodating various edits. (b) A comparison between the post-printed image and the simulation image.

As shown in Figure 7(a) (d), we demonstrated tone adjustments and optimizations. In both of tone adjustments and optimizations, our prediction model is useful based on the measurement data. Additionally, as shown in Figure 7(e), comparing the predicted data with the actual printed results, we observe that they appear almost identical visually.

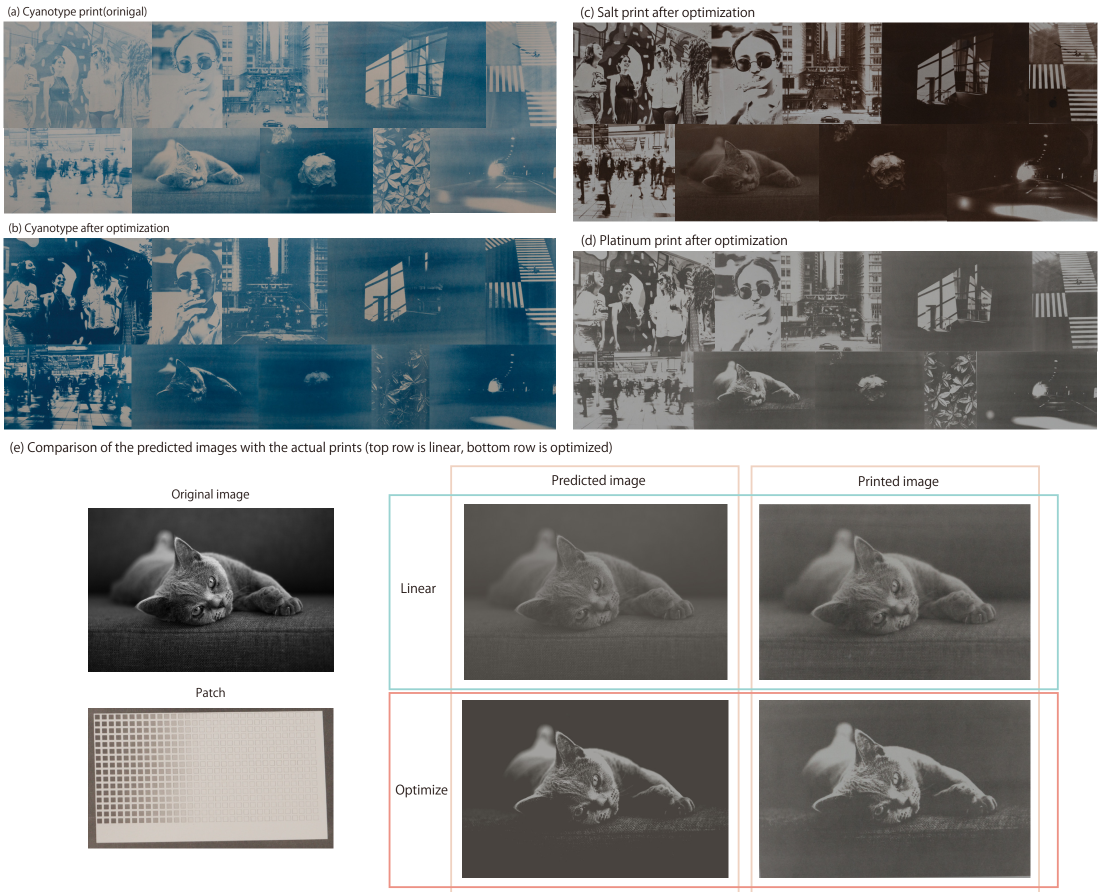

Figure 7: Before and after demonstration of cyanotype: (a) cyanotype print before computational tone adjustment, and (b) cyanotype print after employing our prediction and optimization model to adjust the tones, showcasing a visually striking and distinct outcome. (c) Salt print and (d) platinum print demonstrations employing computational tone adjustment: salt print and platinum print after implementing our computational model to refine image tones and achieve unique aesthetic results.

6 DISCUSSION

The integration of digital and material techniques unlocks a treasure trove of creative possibilities for photographers and artists, while also enabling valuable insights into the production processes, experimental approaches, and legacies of historical artists. By digitizing and analyzing older artworks, researchers can reinterpret past artists' creative intentions, examine their distinct techniques, and unearth previously unknown aspects of photographic history. Simultaneously, the fusion of computational and alternative processes serves as a wellspring of inspiration for contemporary artists, fostering a rich dialogue across different periods and artistic movements. The digitalization of historical alternative processes empowers modern photographers and artists to re-contextualize the methods and aesthetics of the past, stimulating reinvention and innovation while preserving the unique artistic heritage embodied in these techniques. By exploring the fertile ground between analog and digital realms through the utilization of methods such as digital negatives and the incorporation of modern technologies like artificial intelligence and virtual reality, photographers and artists can expand their creative repertoire and push the boundaries of photographic expression. This merging of computational and alternative processes fosters a dynamic, evolving framework that empowers artists to continually redefine photographic possibilities and push their creative limits. The fusion of digital and material techniques in photography enables the medium to be approached as not only a means of expression but also as a continually evolving art form that transcends time and technological boundaries.

7 CONCLUSION

Our technical contribution in image editing with UI and optimization for alternative photographic processes enables the creation of precise and accurate digital negatives. By fusing computer graphics with traditional art techniques, photographers and artists can generate distinctive and expressive works that surpass conventional photographic limits. Through a mindful approach to materials, techniques, and processes, our method enhances the creative possibilities for photographers and artists, enabling unique visual outcomes. Ultimately, our image optimization technique in alternative processes not only broadens the artistic scope but also fosters cultural enrichment within our society.

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