

A proposed methodology for colorizing historical grayscale images: Using image editing and artificial intelligence applications

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Abstract

Humanity has a vast wealth of historical grayscale images, which tell the history of this world. Colorization of historical images began in the 1990s by using professional image processing applications and artificial intelligence. Ten years ago, using artificial intelligence applications based on deep learning expanded to execute restoration and colorization of historical images. However, there are problems related to the quality of production, such as the accuracy of the color tones of historical image elements due to the lack of historical information about the image content in artificial intelligence applications, in addition to the lack of an approved system that codifies the uses of these programs to obtain the required quality. Therefore, this research aims to reach standards and design a production system for coloring old grayscale images, increasing the quality of coloring and technical specifications for use in printed and visual media. The researcher adopted the experimental descriptive approach to propose a methodology that combines the use of artificial intelligence applications and professional image processing applications to carry out restoration and coloring operations more accurately with the intervention of the human element and to determine the sequential and overlapping production processes and the final specifications of the image files. The researcher recommends cooperation between developers of artificial applications and specialists in image processing to develop these systems, and so between developers and historians to provide artificial intelligence applications with historical information from reliable sources to improve the results of color processing of images.

Keywords

Coloring historical images - artificial intelligence applications - restoration of historical photos - grayscale image processing.

الملخص

تمتلك البشرية رصيماً هائلاً من الصور الفوتوغرافية ذات الدرجات الرمادية المتدرجة التاريخية التي تحكي تاريخ هذا العالم. ولقد بدأت عمليات التلوين للصور التاريخية في تسعينيات القرن الماضي باستخدام تطبيقات معالجة الصور المحترفة والذكاء الاصطناعي. وفي السنوات العشر الأخيرة تم التوسع في استخدام تطبيقات الذكاء الاصطناعي القائمة على التعلم العميق في اجراء معالجات الترميم والتلوين للصور. ومع ذلك فهناك مشكلات تتعلق بجودة الإنتاج مثل صحة درجات الألوان لعناصر الصورة التاريخية لنقص المعلومات التاريخية عن محتوى الصورة لدى تطبيقات الذكاء الاصطناعي، بالإضافة لافتقار وجود منظومة معتمدة تقن استخدامات هذه البرامج للحصول على الجودة المطلوبة. لذا يهدف هذا البحث للتوصل لمعايير تُستخدم في تصميم نظام انتاج لتلوين الصور الرمادية التاريخية يزيد من جودة التلوين

والمواصفات التقنية للصور تُستخدم في الوسائط المطبوعة والمرئية. وقد انتهج الباحث المنهج الوصفي التجريبي لكي يقترح منهجية تجمع بين استخدام تطبيقات الذكاء الاصطناعي وتطبيقات معالجة الصور المحترفة لإجراء عمليات الترميم والتلوين بصورة أكثر دقة بتدخل العنصر البشري، وتحديد العمليات الإنتاجية المتتابعة والمتداخلة والمواصفات النهائية لملفات الصور. ويوصي الباحث بالتعاون بين مطوري التطبيقات الإصطناعية والمتخصصين في معالجة الصور لتطوير هذه النظم، وكذلك بين المطورين والمؤرخين لإمداد تطبيقات الذكاء الاصطناعي بالمعلومات التاريخية من مصادر موثوقة لتحسين نتائج المعالجات اللونية.

الكلمات المفتاحية

تلوين الصور التاريخية، تطبيقات الذكاء الاصطناعي، ترميم الصور التاريخية، معالجة الصور الرمادية

Introduction

Coloring historical grayscale images is a significant responsibility, for enhancing accessibility and engagement with the past. Adding realistic colors to grayscale images can bridge the gap between the present and the historical moments captured in these images. Colorization also helps us visualize the past in clarity, making it more relatable to a wider audience. However, achieving accurate and realistic colorization poses several challenges. One of the main challenges is determining the appropriate or real colors for objects, buildings, cars, places, and people in the images, especially when limited references or documentation is available. The designer must be careful not to impose new directions or personal biases on the past and the original substance and photographer's vision must be respected. Secondly, ethics are relevant; permission from image owners or relatives is essential, especially for traumatic or sensitive images. Not to forget to be careful to avoid changing or manipulating the faces or feelings of the people in the image. Thirdly, it's also critical to recognize the constraints and uncertainties inherent in the colorization process, since perfect accuracy may not always be achievable. Based upon this, the main aim of this paper is to develop a realistic and customized proposed methodology for coloring historical grayscale images. Furthermore, this proposed methodology will attempt to address the primary difficulties and employ appropriate colorization strategies, to guarantee the greatest results possible, it will consider the application of manual techniques, AI tools, and ethical considerations.

The Research Problem:

- There is no authorized methodology for colorizing historical grayscale images.
- The inability of AI applications (desktop and web applications) that use deep learning to produce accurate final results when used to colorize historical grayscale images.

The Research aim:

- Proposing a methodology for colorizing historical grayscale images using artificial intelligence and image processing applications.

The Research Importance:

This study contributes to engagement with the past by proposing a production system for colorizing historical grayscale images to achieve accurate and visually acceptable colorization results while addressing technical issues and maintaining historical authenticity and ethical considerations. The suggested methods combine image editing apps, deep learning technologies, and human intervention to provide the best colorization outcomes. In addition, using quality control tools and techniques, feedback loops, and collaboration with professional historians will lead to accurate final results.

The Research Methodology:

The researcher utilized two approaches: First, the analytical approach examines why current artificial intelligence applications do not achieve perfect results when colorizing historical grayscale images. Second, the experimental approach proposes a methodology combining artificial intelligence and image processing applications for coloring historical grayscale images.

1- Using the AI Applications coloring the historical grayscale images:

AI is a computer system capable of performing tasks that typically require human intelligence, such as understanding human language, recognizing data patterns, image processing, and adding artistic effects. (Davis, 2024) Recently, we used AI tools and applications incorporated into online and desktop applications to colorize greyscale images by analyzing the contents of images and accurately assigning colors to the buildings, cars, people, animals, and furniture then coloring them. AI applications and tools automatically enhance, modify, or create images. Furthermore, image editing AI applications can crop, resize, color correction, noise reduction, sky replacement, and more. (Wayne, 2024) There are three types of AI applications types for coloring grayscale images: Desktop, online, and mobile (shown in Fig1).

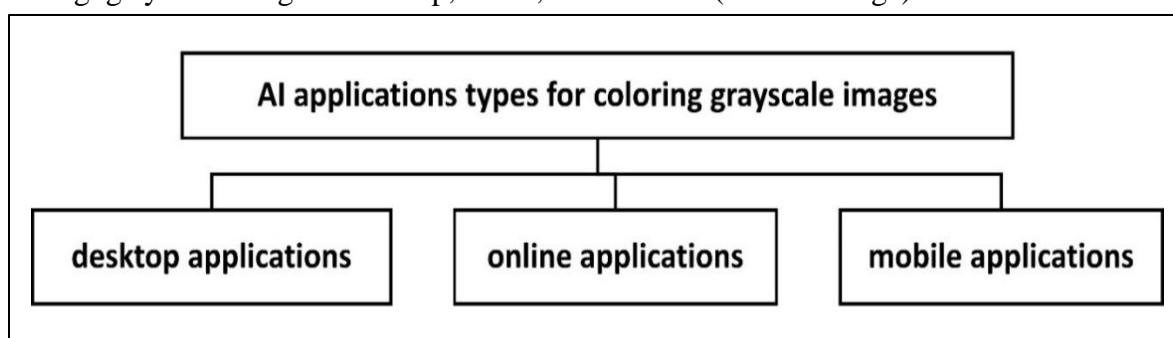


FIGURE 1: AI APPLICATIONS TYPES FOR COLORING GRAYSCALE IMAGES

The researcher compared all of them to assess the main advantages and disadvantages of each one (shown in Table 1). Therefore, the research will focus on desktop and online apps to develop a professional production system for coloring historical grayscale images.

TABLE 1: COMPARISON AMONG DIFFERENT AI APPLICATION TYPES COLORING HISTORICAL GRAYSCALE IMAGES

Aspect	Online Applications	Desktop Applications	Mobile Applications
Accessibility	Web-based, no installation needed	Requires installation on your PC	Available as mobile apps
Ease of Use	Intuitive interface	Professional level	User-friendly interfaces
AI Coloring	Utilizes AI algorithms	Offers advanced customization	Some mobile apps use AI
Speed	Quick results	Take longer for complex edits	Instant colorization on mobile
Offline Use	Requires internet connection	Works offline	Sometimes, Available offline
Quality	Varies - less control	Higher quality, human control	Quality varies by app
Artistic Control	Limited	Extensive control over adjustments	Varies (some apps offer control)
Workflow Efficiency	N/A	Efficient for complex projects	Ideal for quick, on-the-go tasks
Collaboration	N/A	Seamless collaboration features	Limited (desktop apps excel here)
File Formats	JPEG – PNG - TIFF	Supports industry-standard formats	Limited (depends on the app)

It is necessary to distinguish between an AI model and an AI system as units of final results assessment (shown in Fig 2). An AI model typically involves some input data, a pattern-matching algorithm, and an output classification (Anja, 2022).

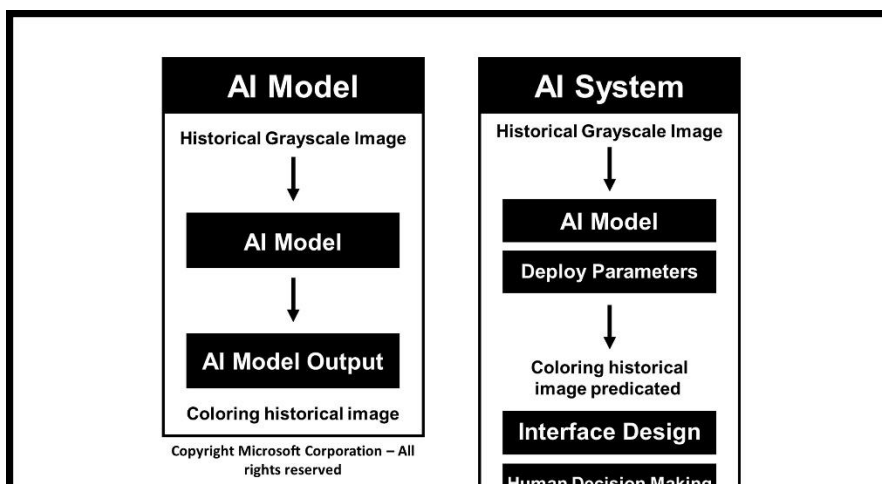


FIGURE 2: PERFORMANCE ASSESSMENT FOR AI MODEL AND AI SYSTEM –

MODIFIED BY THE RESEARCHER (THIEME, 2022)

For example, using an AI model to color a historical grayscale image, the AI model will color it without evaluating the image status, such as the need to have restoration or color correction. Consequently, human intervention is required to select the production processes of restorations and the accurate values of colors. The researcher used some AI online models such as img2go, image colorizer, and Phot AI. The AI models were colored without any modification to the quality level before coloring (shown in Fig 3). Therefore, the researcher used Adobe Photoshop first (desktop image editing Application) to make color corrections and retouching. Secondly, he used the Gigapixel AI (desktop application) to perform restoration processes such as suppressing noise, removing blur, and redefining the face to improve the final grayscale image before coloring. Thirdly, he checked the image state and noticed that the image needed some manual retouching by using the Adobe Photoshop application again and he did it (shown in Fig 4).

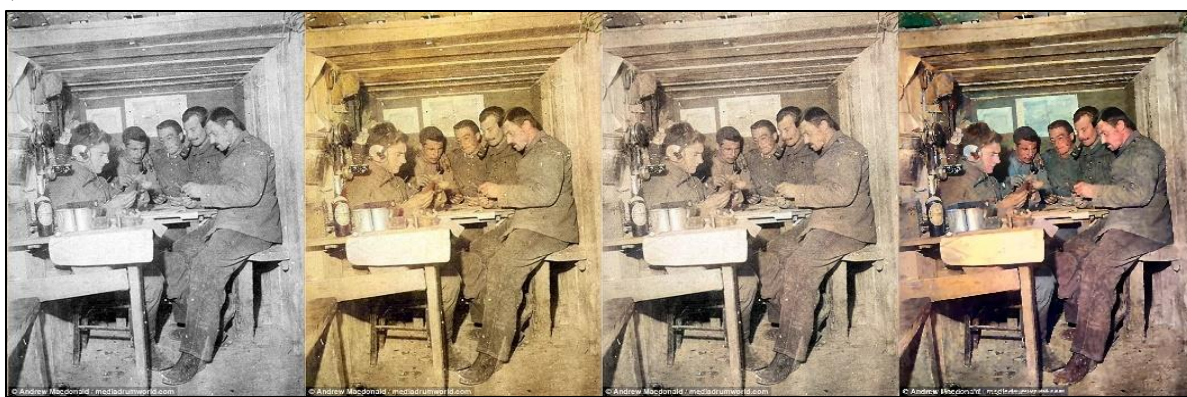


Figure 3: AI models colored the historical image without making restoration processes
 “GERMAN SOLDIERS IN DUGOUT ON SOMME. ANDREW MACDONALD / MEDIADRUMLIANA, 2017”

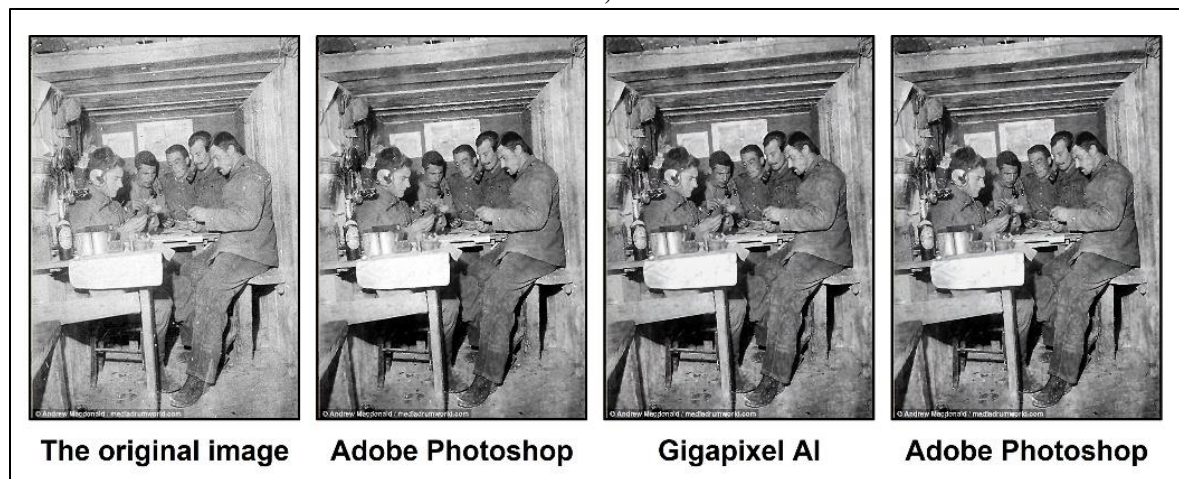


FIGURE 4: MAKING RESTORATION PROCESSES BY USING ADOBE PHOTOSHOP AND THE GIGAPIXEL AI APPLICATION

Finally, he colored the improved historical grayscale image by using online AI models and the final results were better than the images without restorations but the colors were not right (shown in Fig 5). The researcher collected information about the image and he found the image contained some German Soldiers in Dugout on Somme and the capture of Schwaben Redoubt in the First World War 1916 (Jacob Liana, 2017). Accordingly, the soldiers' uniform must be

dark blue because the main historical references told us and the colorist can complete the coloring process by using historical references without biasing or predicting.

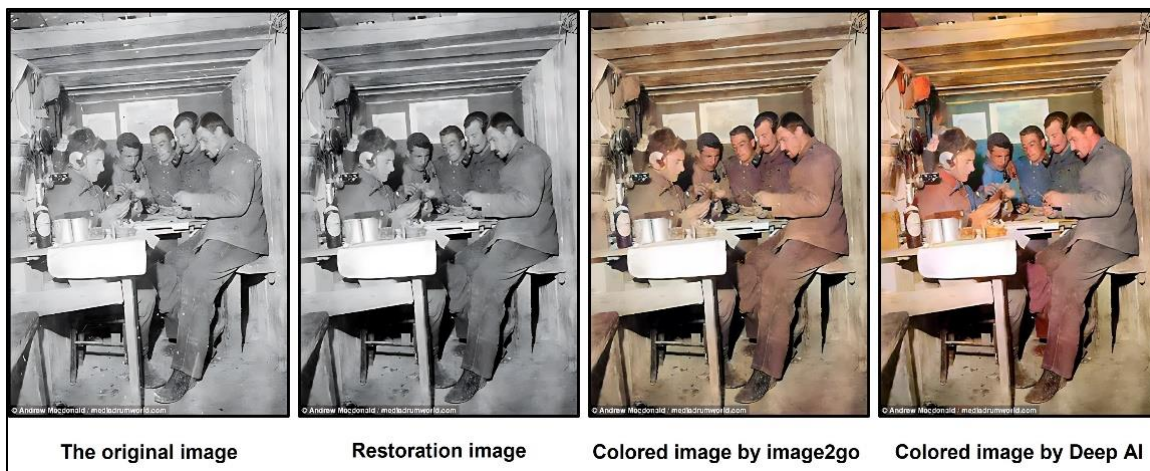


FIGURE 5: MAKING RESTORATION AND COLORING PROCESSES FOR THE HISTORICAL GRAYSCALE IMAGE BY USING DESKTOP IMAGE EDITING APPLICATION AND ONLINE AI MODELS

On the other hand, An AI system, by contrast, would evaluate a broader range of information about the image beyond the coloring process alone. We expected the AI system to suggest restoration operations such as color corrections, retouching, and appropriate accurate colors for this image and then perform the coloring process. Therefore, computer science researchers have developed neural networks that are more automatic by proposing deep learning models for converting general grayscale images into color. Where these fully automatic models will lead to valorizing and enhancing historical images, adding colors can help to revitalize archival sources, improve the scene’s understanding, and support the analysis of past urban scenarios, landscapes, lifestyles, and settlements (Farella, 2022).

However, the current deep learning-based models cannot precisely control the coloring results of grayscale images because they are still models and not systems (Yu Chen, 2022). This confirms that the collaboration between humans and artificial intelligence can increase the accuracy of artificial intelligence models alone (Bansal, 2021). (Bansal, 2021).

Neither the deep learning models nor the human intervention approaches can color grayscale images without causing quality problems (Pierre, 2021). Consequentially, the researcher proposes a methodology that combines professional image processing applications with human intervention to implement all required processes for coloring historical grayscale images.

2- The main characteristics of coloring historical grayscale images

Three major characteristics influence the outcome of historical grayscale picture processing. (Shown in Fig 6):

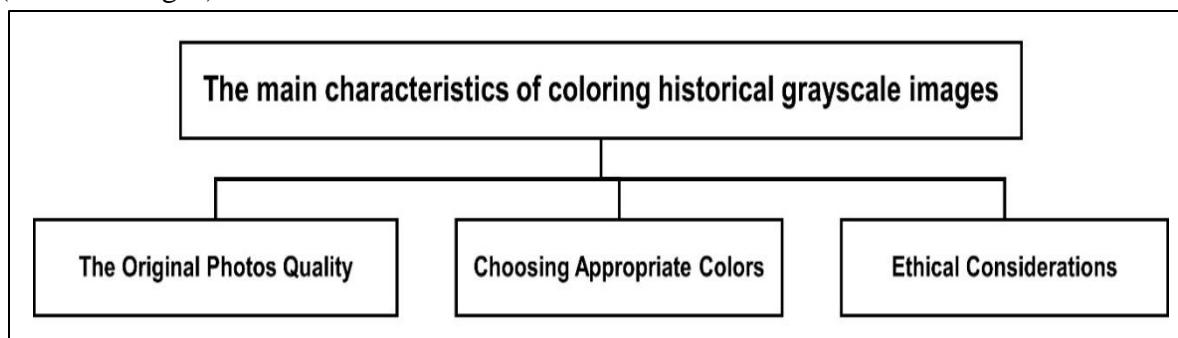


FIGURE 6: THE MAIN CHARACTERISTICS OF COLORING HISTORICAL GRAYSCALE IMAGES

2-1 The Original Photos Quality:

The printed historical grayscale photos deteriorate when kept in poor environmental conditions, which causes the valuable image content permanently damaged. Generally, have fading, creasing, blurring, low details, scratches, dust spots, or have been erased, all of which have an impact on coloring accuracy and the result. So, the designers need to use additional restoration techniques, such as retouching and color corrections, to solve these problems and enhance them before starting the coloring process. Therefore, specialists will make the restorations using AI or professional desktop applications such as VanceAI Photo Restorer, Adobe Photoshop Express, AKVIS Retoucher, AVCLabs PhotoPro AI, Luminar Neo, Face Restore, and Corel Paintshop Pro. (Williams, 2024)

For example, the images in Figure 7 had different types of damages, such as cracks, scratches, missing parts, and creases, and a specialist made many types of repairs using various technologies and multiple applications. (Wan, 2020)



FIGURE 7: THE RESTORATION PROCESSES FOR EXAMPLE IMAGES THAT HAD DIFFERENT TYPES OF DAMAGE AND RECEIVED DIFFERENT REPAIRS BEFORE COLORING – (ALEX M., 2024)

2-2 Choosing Appropriate Colors:

The grayscale historical images connect the past and present with many relationships and memories. Converting them to colored images would make them more visually appealing. The colorist uses desktop image editing applications such as Photoshop to perform the coloring process, which takes a long time. In recent years, deep-learning models have greatly accelerated the coloring process and even automated it (Pyngrope, 2022). Although using manual



techniques for coloring grayscale images appears simple, the choice of multiple alternative hues for numerous objects may make the process more complex. Although certain objects have set natural hues, such as the sky being blue and grapes being yellow, red, and green, others may appear in nature with an unlimited range of colors, for example, a balloon can be any color. Furthermore, an object's hue might change depending on the lighting conditions in its surroundings, such as the color of the sky, which changes from sunrise to sunset during the day and completely at night. The elements listed above are examples of problems that make the coloring process more challenging (Noaman, 2022). So, choosing the right colors for historical grayscale images can be difficult because there may be little available information about the original colors of the contents, such as people, fashion, furniture, animals, buildings, cars, carpets, shoes, etc... For instance, when the designer wants to color a car, he needs to know the car model and the colors for this model in the same year. Without this information, he will suggest different colors depending on his experience and preference (shown in Fig. 8).

Figure 8: The designers colored the old car model based on their point of view (pickpik – 2024)

This problem also occurs when the designer uses different AI models to colorize the same image, and he gets different results because the AI models use the coloring techniques without any information about the image, as (shown in Fig. 9).

As a result, human intervention is a major factor in determining the required colors for specific areas in the historical grayscale images, and colorists must make their final decisions using a variety of historical resources such as research, professional historians, books, magazines, old people's stories, old movies, historical encyclopedias, and popular heritage.



**Figure 9: Using different AI models to colorize and get different results –
 A STREET PEDDLER IN 1935 – (EGYPTIAN STREETS, 2013)**

For instance, a professional colorist colored a grayscale image (shown in Fig. 10 and Fig. 11) by using Adobe Photoshop and many online AI models. Then, we checked the final results and found that the colorist's final outputs fare better than those of AI models. In addition, the researcher analyzed the contents of the image in Fig 11 before coloring it by collecting all the important information and details (shown in Fig. 12).

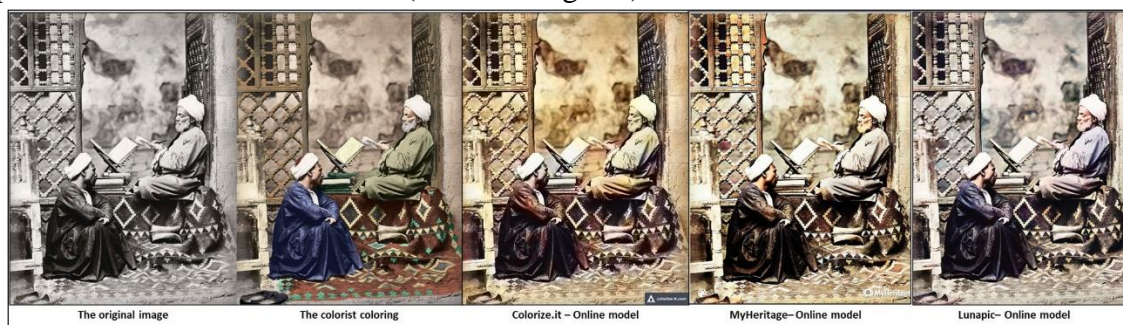


FIGURE 10: COMPARING BETWEEN THE COLORING RESULTS OF THE HUMAN COLORIST AND DIFFERENT AI MODELS LATE 19TH-CENTURY PHOTOGRAPH - MUSLIM RELIGIOUS TEACHER, EGYPT, C.1880'S - (MONO VISIONS, 2017)



FIGURE 11: COMPARING BETWEEN THE COLORING RESULTS OF THE HUMAN COLORIST AND DIFFERENT AI MODELS AUTO WRECK, WASHINGTON, D.C., USA, 1923. A CHEVROLET 490 - (WIKIMEDIA, 2009)

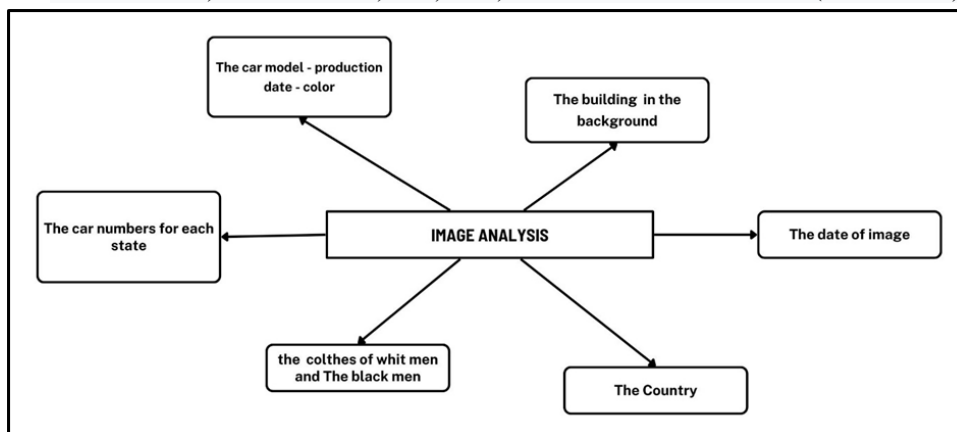


FIGURE 12: ANALYZING THE CONTENTS OF THE HISTORICAL GRAYSCALE IMAGE

2-3 Ethical Considerations:

In 2021, an Irish artist colorized and added smiles to photos of tortured prisoners from Security Prison 21 in Phnom Penh, Cambodia, which was used by the Khmer Rouge from 1975-79. His photos were published on the Vice website. Then, Vice removed the altered photos from their website and apologized to the families of the victims and the communities in Cambodia (shown in Fig. 13) (Schneider, 2021).



FIGURE 13: THE PHOTO OF CAMBODIAN PRISONERS THAT WERE COLORED AND THE ARTIST ADDED SMILES. THE VICE WEBSITE PUBLISHED IT THEN, REMOVED IT LATER, AND APOLOGIZED TO THE FAMILIES OF THE VICTIMS. (SCHNEIDER, 2021)

The availability of deep learning models would make photo coloring easier for anyone to colorize photos. Like any technology, it is crucial to keep in mind the potentially dangerous applications of one's work (Olah, 2022).

Coloring historical photos raises ethical concerns that require careful consideration, and it is critical to respect the original intent of the photos and avoid biases. Furthermore, the coloring process may distort the content of the original image, like changing the skin of a black person to be lighter or the colorization distorts the historical accuracy and authenticity of the photo, as it changes the lighting, contrast, and details of the original image (Schneider, 2021). Therefore, the researcher suggests developing ethical standards and guidelines to oblige the colorists and the designers to:

- Maintain honesty and transparency throughout the production process.
- They may need to obtain agreement from relevant parties or their descendants.
- Avoid manipulating the emotions or expressions of the people in the images.
- Avoid imposing modern or personal biases on the past.
- Respect the original intent and context of the photographers and the subjects.
- Balance the trade-offs between realism and aesthetics.
- Provide information about the techniques, applications, and references used.

3. The proposed methodology for the coloring Production System:

Based on the findings from previous phases of the research, the researcher proposes a methodology for colorizing historical grayscale images with desktop image editing and artificial intelligence applications. The methodology consists of the following major components:

3.1 The inputs for the coloring Production System

The main inputs are (shown in Fig. 14) and there are some considerations such as: -

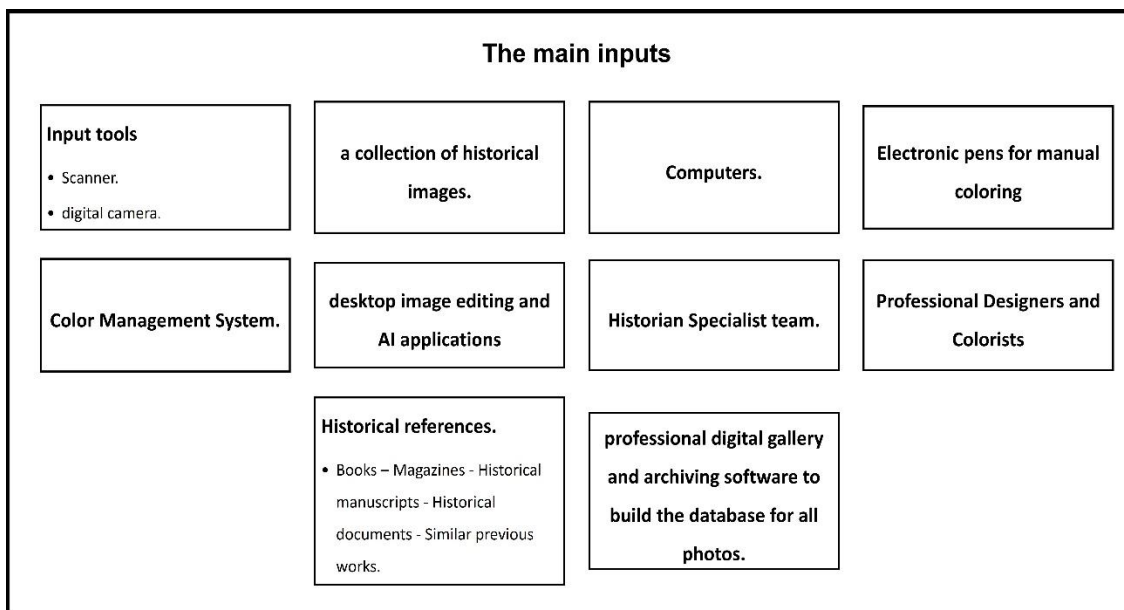


Figure 14: The inputs of the coloring Production System for historical grayscale images

- The production team comprises image restorers, colorists, and historians.
- Selecting the applications for each production stage depends on the status of the images and the production plans.
- The applications are available in both desktop and web versions, with varying levels of functionality and quality. As a result, we can use them in the restoration and coloring processes to produce colored images that meet the desired technical specifications as shown in details in Fig. 15.
- The teamwork consists of Designers, colorists, the historian Specialist team, and cultural advisors.
- Using an appropriate color management system will support the colorist in making decisions during the coloring process by choosing the right colors.
- Use different historical references, such as books, magazines, Historical manuscripts, and Similar previous works to know the required information about the contents of images.
- The colorist can use a professional application to build a database for all historical images and add information about each image, such as the content, main elements, date, location, and size.

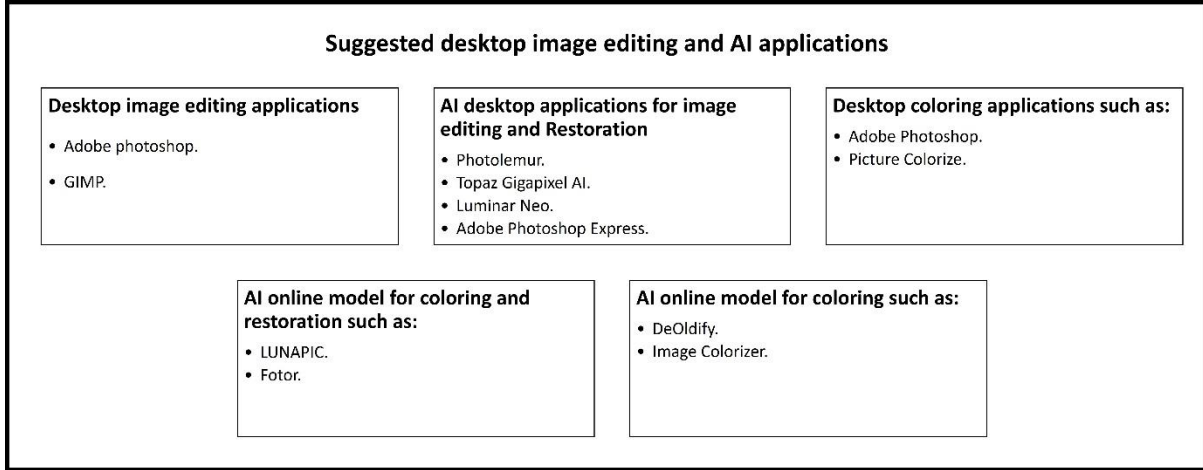


Figure 15: Suggested desktop image editing and AI applications for coloring the historical grayscale images

3.2 The Main production processes

The researcher provided the key production procedures for coloring the historical grayscale images, as shown in Fig. 16. However, there are some managerial and technical requirements when the team uses these processes:

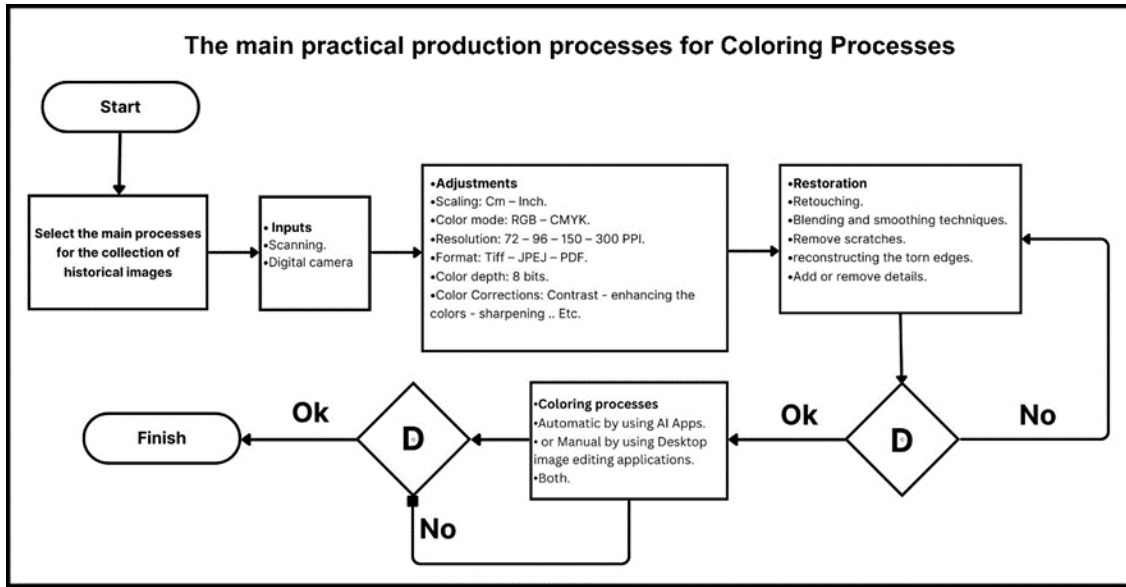


FIGURE 16: THE MAIN PRACTICAL PRODUCTION PROCESSES FOR COLORING HISTORICAL GRAYSCALE IMAGES

- Establish guidelines and research best practices for color selection based on historical context and references.
- Collaborate with experts, historians, or cultural advisors to ensure accuracy and avoid biases.
- Document the colorization process and provide explanations for color choices, promoting transparency and accountability.
- Combine multiple sources of information, such as historical references or expert knowledge, to make informed assumptions about colors in cases where the original details are unclear.

- Select an AI tool suitable for historical photo restoration.
- Upload the photos to the AI online tool and follow the instructions.
- Adjust the parameters to fine-tune the output according to desired preferences.
- After the AI restoration process, review the results to assess accuracy and quality.
- Identify areas that require manual editing to improve the final results.
- Use any desktop image editing application, such as Adobe Photoshop, to refine the coloring manually.
- Establish quality control criteria to ensure accurate final results such as the resolution, the scale, the accepted details, color values, and the originality.
- The colorists iterate and refine the colorization process in response to feedback and continual improvement efforts.
- Organizing feedback sessions with clients and stockholders to ensure their satisfaction with the final coloring images.

Conclusion

This study looked into the complexities of colorizing historical grayscale images, showing the inherent risks of relying only on artificial intelligence. While AI techniques provide a quick and decreasingly complex method of coloring, they typically fall short in terms of literal delicacy and visual devotion. This is mostly due to AI's shortcomings in interpreting contextual information, which results in inaccurate color selections and a lack of fine detail. The proposed methodology stresses a collaborative approach that combines the powers of AI operations with the skills of human colorists and the accuracy of chroniclers. This collaborative approach ensures that the experts control the coloring process, and applying the suggested methodology will produce colored historical images that are visually appealing and accepted by including stringent quality control measures, feedback loops, and ethical considerations.

Results

- The comparative analysis of AI models and human colorists revealed a significant disparity in the quality of colorized images.
- While AI models excelled in speed and automation, their outputs often lacked the accuracy and attention to detail exhibited by human colorists.
- The colorization process must respect historical authenticity, avoid modern biases, and preserve the emotions and expressions of the people in the historical grayscale images.
- This discrepancy underscores the importance of human intervention in the colorization process, particularly in interpreting historical context, selecting appropriate colors, and ensuring ethical considerations are met.
- The experimental application of the proposed methodology, incorporating both AI tools and professional desktop image editing applications, yielded promising results.
- The integration of historical research and expert feedback will lead to a marked improvement in the accuracy and realism of colored images compared to those produced solely by AI models.
- Quality control measures and feedback loops will maintain accuracy and meet the expectations of users or stakeholders.

Recommendations

- We must collaborate with AI developers and image-processing specialists to create sophisticated AI systems with contextual awareness and historical sensitivity.
- It is better to integrate historical databases into AI training datasets by training AI models on extensive datasets enriched with historical information, such as period-specific color palettes, fashion trends, and architectural styles, the accuracy and authenticity of AI-powered colorization can be significantly enhanced.
- It is essential to establish ethical guidelines for historical image coloring to help maintain historical integrity, avoid biases, and acknowledge the sensitive nature of certain historical events and individuals.
- The concerned authorities must support transparency and documenting methodologies, color choices, and historical references to facilitate future research and analysis.
- The concerned authorities should collaborate with operators, agencies, and clients to create a feedback loop to develop a feedback loop and address any concerns.

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