

## RESTORATION OF OLD PHOTOGRAPHS USING AI APPLICATIONS

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**Abstract:** Restoration of old photographs is a demanding task that requires a lot of skill and attention to detail. It can involve many different steps in photo editing and, until recently, was almost always done by photo editing professionals. Thanks to numerous photo editing AI applications, nowadays even the inexperienced users can perform this task. However, the results may not always be satisfactory. In this work, we evaluated the effectiveness of different free web-based AI applications in restoring old photographs that exhibited the most frequently seen damage. Tested AI solutions enabled significantly faster photo editing compared to manual techniques, while still providing visually pleasing results. On the other hand, they showed tendency to smooth out graininess, important details, and textures in images. When automatic processing failed to correct certain details, the results heavily depended on the user's skill to recognize and mark the errors for post-processing. Therefore, we believe that AI tools for photo restoration are a great choice for fast image processing, but their outcomes should be manually adjusted to ensure the authenticity and naturalness of old photographs.

**Key words:** photo restoration, AI software, old photographs, photo editing

### 1. INTRODUCTION

The term 'old photography' informally refers to photographs taken in the past, typically before the widespread use of digital cameras, i.e., from the 19th to the mid-20th century (Moorshead & Chapman, 2000). It does not refer to a single technology, but includes every type of analogue photography - from early photographic processes to the film cameras many of us still remember. Therefore, 'old photography' encompasses a wide range of historical periods and styles (Frisch-Ripley, 1991). Photographs were printed on paper using various techniques (Mulligan & Wooters, 2012), and often hold historical, emotional, and/or cultural value. Preserving old photographs is essential for safeguarding memories and historical moments for future generations.

To adequately preserve old photographs, they must be stored and handled properly. Even with proper care, the materials used in their production deteriorate over time. The most evident change is fading – image became less vivid, details tend to blur and disappear, and the paper colour shift to yellow.

There are many other changes and errors that can be seen in old photographs. They can be caused by both internal (nature of the process and the durability of the materials used) and external factors (mechanical, environmental and other external influences) (Tamino Autographs, 2022). Damage caused by the internal factors are often observed as discolorations and other changes of colour and contrast, excessive graininess, dots and lines (if information was transferred from the film that was scratched), solarization and many others (Van Camp, 2010; Xu et al., 2023). On the other hand, mechanical damage can be seen as scratches, cracks, tears, loose emulsion, blots and stains, traces of adhesive tape, additional inscriptions, seals, glue residues, etc. (Tamino Autographs, 2022; Xu et al., 2023).

The process of repairing and enhancing old, damaged or deteriorated photographs, with the intention to return them to their original or even improved state, is known as photo restoration (Whitman, 2023; Lin, 2024). It is a challenging process that requires both technical skills and artistic abilities, as well as a lot of patience and attention to detail (Whitman, 2023). Photograph had to be properly evaluated in order to get an idea of how it looked in the past. All the damage needed to be meticulously restored, which can even require reconstructing the missing parts.

As photography transitioned from analogue to digital, photo restoration followed the same path. Digital tools revolutionized the field by enabling precise and controlled correction and enhancement of digital images, while offering photographers greater flexibility in making adjustments (Whitman, 2023). Digital photo restoration does not involve any physical manipulation of the analogue photography, except of its digitization, and is stated to produce better results in comparison to manual techniques (Ctein, 2010; Whitman, 2023).

In recent years, we have witnessed a new advancement in the revival of old photographs: AI-powered image restoration. Artificial intelligence is nowadays able to create photographs, so it is no surprise that it can also restore them.

There are many AI software solutions for photo editing and restoration. Some of them rely on models specialized in correcting specific errors, while others employ more general ones (Wan et al., 2020). Key functions providing fast and efficient results in restoring old photos include scratches removal, colour restoration, detail enhancement and sharpening, noise reduction, facial features enhancement and reconstruction of details (Xu et al., 2023; Tang, 2024; Lin, 2024). These functions rely on deep learning methods, where complex neural networks are trained on extensive datasets containing both damaged and restored photos, to enable accurate learning and effective restoration (Wan et al, 2020; Xu et al, 2023). In addition, newly proposed model (Conde et al., 2024) incorporate natural language processing, and is designed to restore images by following human-written instructions.

The effectiveness of AI tools mostly depends on the dataset used for the training, as well as the proper training of the model. Since the lost or damaged parts of the photograph are generated from the scratch, the results can sometimes look unnatural.

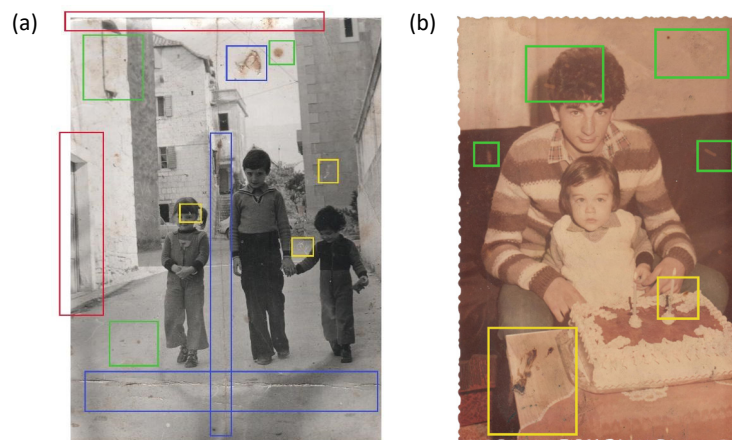
In this study, we evaluated free web-based AI applications designed to correct and restore old photographs. The objective was to assess the effectiveness of widely accessible AI tools in addressing various types of damage present in old photographs and, ultimately, in producing images that appear natural and visually coherent.

## 2. METHOD

For the purpose of this work, we chose two old photographs that belong to the corresponding author of this paper – one black-and-white (Figure 1a) and one in colour (Figure 1b). The photographs were selected because they exhibited a range of common deteriorations typically observed in old images. Different kinds of damage were caused both by the aging and an inadequate storage of the photographs.

Due to improper storage conditions, both photographs exhibit visible stains, spots, and specks on their surfaces, likely caused by dust accumulation and soiling (Figure 1). Additionally, the photographs show signs of fading and mechanical damage, including scratches. In the black-and-white photograph surface cracking, splitting, and larger stains on the surface structure can be seen, as well as creases resulting from bending (Figure 1a). The colour photograph also shows a lack of contrast, slightly yellowish tone and reduced saturation (Figure 1b).

The selected photographs were scanned using the HP LaserJet M1120 MFP multifunction device. The scanning was conducted at a resolution of 300 ppi in the RGB colour space. Before further processing, the black background present after scanning was removed. In order to preserve jagged edges of colour photograph (Figure 1b), removing of the black background was done in Photoshop 2022. The image was saved in PNG format so as to preserve transparency.



*Figure 1: Selected photographs: (a) black-and-white and (b) colour. Various types of damage are highlighted with the following colour codes: red – colour fading; yellow – scratches; blue – cracks, creases, and torn areas; green – blots and stains.*

When choosing AI applications for photo restoration we focused on the options that are available to the most of the users. Hence, only free programs that don't require installation and operate online were selected. An analysis of the available solutions revealed that no single application could correct all types of damage seen in the photographs. Therefore, a combination of different software tools was required to restore the photographs properly.

After researching and testing different solutions (such as Bringing-old-photos-back-to-life, Restorephotos.io, Repairit, MyHeritage, Hotpot, Pixelcut, PhotoBooth, PicWish), we decided to use Nero AI, SnapEdit and Fotor (Nero AI, 2024; SnapEdit, 2024; Fotor, 2024). These applications were shown to be easy to use, they offer a range of options for solving specific problems, and provide very good results with minimal effort.

The Nero AI was used to correct creases and torn areas in photos, as well as to blend stains and scratches. SnapEdit was employed for additional stain removal and texture correction, while colour and contrast corrections were done in Fotor. The detailed steps of photo reconstruction process, as well as the obtained results are presented as follows.

### 3. RESULTS

#### 3.1. Reconstruction of black-and-white photograph

On Nero AI website (Nero AI, 2024) *Photo restoration* option can be found in the menu *AI Tools*. Upon uploading an image, there are three options - *Scratch fix*, *Colorize* and *Face enhancement*. We chose to correct the scratches, and the application automatically corrected all the parts in the photo recognized as ones. After a couple of seconds, the photo with a slider for quick assessment of its appearance before and after the processing was displayed. We had an option to download the photograph, improve its resolution or perform a manual correction.

Since some errors in the sky, road, buildings, children's clothes and faces were not corrected, we chose to reconstruct those parts manually. Option *Manual fix* allowed us to paint over the parts that needed further processing (Figure 2a). It was possible to define the size of the brush to paint with, erase or move previously painted or processed areas. After this step, all the damage marked manually was successfully removed, as shown in Figure 2b.



Figure 2: (a) Parts of the photograph manually marked for further processing and (b) image after the processing

The further corrections included the reconstruction of the sky, buildings and road, faded parts of an image, as well as removal of the spots and stains still visible in the background. All the corrections were done in SnapEdit application by activating option *Remove object* from the menu *AI Products*. The process of reconstructing/removing objects was similar to the previously described – we had to mark parts of an image to be processed and the application perform the correction. In order to obtain better outcome, we corrected the image partially, by marking and processing small regions in each pass (the parts marked when reconstructing the road can be seen in Figure 3a). The results of the correction can be seen in Figure 3b.



Figure 3: (a) Parts of the photographs manually marked when reconstructing the road and (b) image after the processing in SnapEdit

Colour and contrast corrections were performed in Fotor by choosing the option *AI Photo Editor*. Since regions of yellow pixels were noticed in some parts of the photo, to remove the yellow tone we first applied *Grayscale filter* (*Effects/Filters* tab). Of many available filters, we chose *Classic2* with an intensity of 80%. This had improved the contrast of an image to a certain extent, so in the following step the contrast was increased only slightly. The *Contrast* (*Adjust/Basic Adjust* tab) value was set to 20% which resulted in an image shown in Figure 4.



Figure 4: The final result of image processing after colour and contrast correction

### 3.2. Reconstruction of colour photograph

The reconstruction of the colour photograph was performed by following the same steps as in the case of black-and-white photograph. We first employed Nero AI to remove most of the damage including stains, scratches on the wall, bed, table, hair and sweater of the young man, as well as errors on the boy's face. SnapEdit was used for more detailed correction of the wall, jeans, table and tablecloth, while contrast and colour were corrected in Fotor.

In Nero AI we first used *Scratch fix* option, which did not yield satisfactory results. The part of the tablecloth was incorrectly recognized as damage, while some scratches on the table, wall, bedspread and other areas were not removed (Figure 5a). Therefore, as in the previous case, we had to manually mark those parts using *Manual fix* option. Parts that were incorrectly processed were deleted by using *Eraser tool*, and those parts that needed further refinements were marked. The result of this action is shown in Figure 5b.

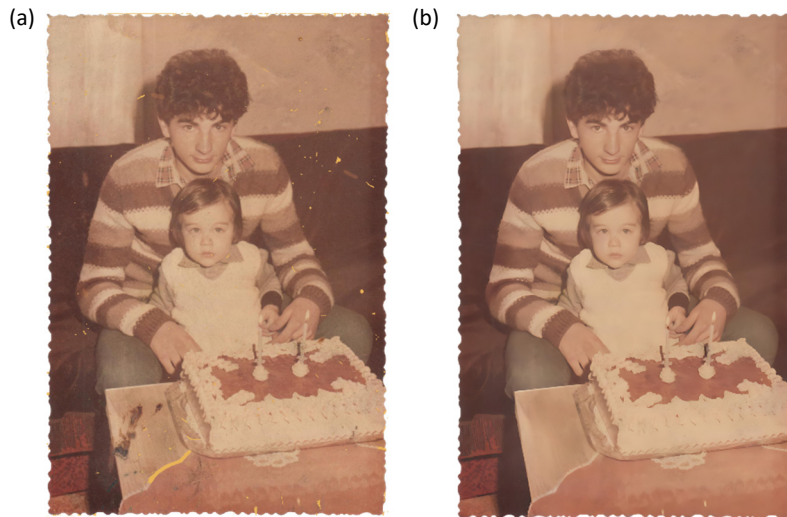


Figure 5: Photograph processed in Nero AI (a) before and (b) after manually fixing all the errors

Additional adjustments were done in SnapEdit in order to correct the texture of the wall, table, tablecloth and jeans. We used Remove object option, and all the parts to be corrected were marked manually, as explained before. The result of this step is shown in Figure 6a.

The colour of the image was corrected in Fotor by applying filter belonging to the *Vintage group*. After testing different options, the best results were achieved with filter *HK film* set to the intensity of 50%. Additional adjustments included correction of the brightness (increased by 5%) and contrast (increased by 30%) (*Adjust/Basic Adjust* tab). The final result of image processing is shown in Figure 6b.

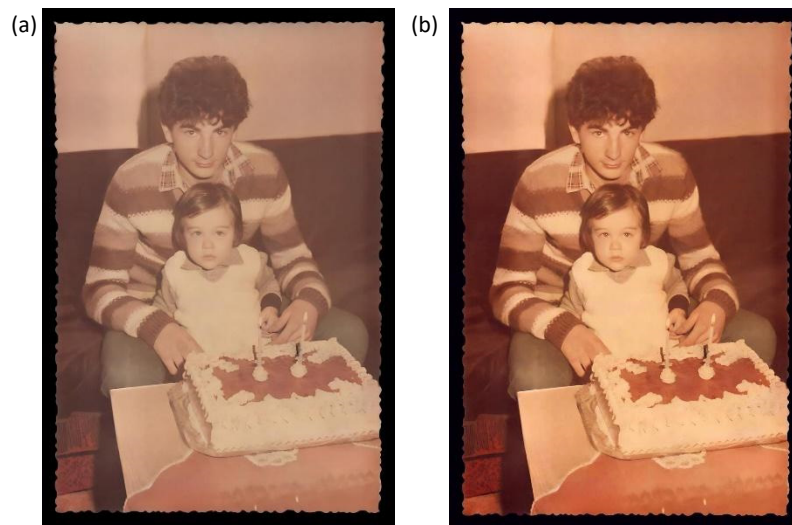


Figure 6: Photograph after processing in (a) SnapEdit and (b) in Fotor

#### 4. DISCUSSION

By comparing original and restored black-and-white photograph (Figure 7) it is evident that AI applications managed to remove all the surface structure damage (like dots and stains), reconstruct the mechanical damage (scratches, tears, bends, folds and cracks on the surface), as well as the worn edges. The contrast and brightness of the photograph had also been improved.

However, it can be also seen that the restored photograph lacks the grain structure, an imminent characteristic of its analogue counterpart. This results in the loss of details and textures in an image. Additionally, the colour correction applied to the door of the building on the left side of the image was inadequate; the upper half of the door was restored, while the lower half remained desaturated,



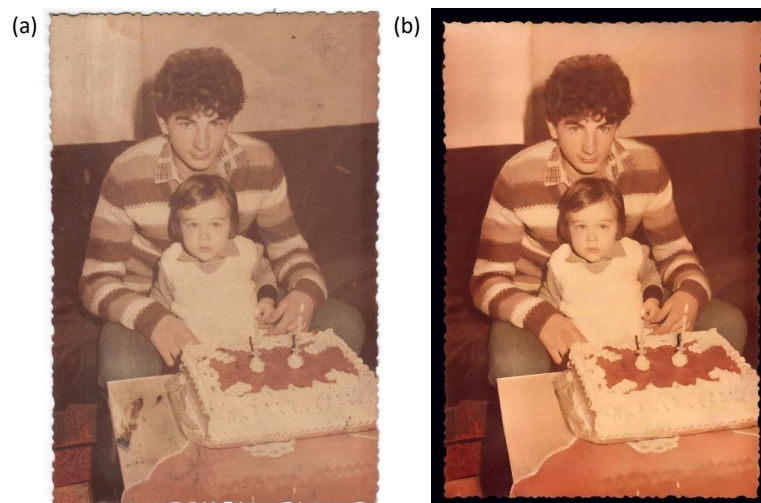
significantly altering the overall appearance. The image also exhibits a loss of details in the background, where certain elements were either removed or inadequately restored, likely due to the complexity of the damaged texture.



*Figure 7: Black-and-white photograph (a) before and (b) after processing in AI-based applications*

The most prominent difference in the colour photography reconstructed using AI-based applications (Figure 8) is a noticeable colour imbalance, with red tones dominating while other colours appear desaturated. Variations in tone are visible on the tablecloth, where colour was not accurately restored on the entire surface. We tried to further adjust the photo, but the options for colour correction were limited and there was no way to alter one colour channel or the selected tones.

Similar to the black-and-white version, the lack of texture is evident in the colour photography as well (Figure 8b). This is particularly noticeable on the boy's sweater, where the fabric's structure has been entirely removed. A reduction in detail is also apparent on the cake. Moreover, the AI software did not accurately recreate the reflection of the cake on the table, nor did it effectively correct damage seen on the small elements (birthday candle on the right, for example).



*Figure 8: Colour photograph a) before and b) after processing in AI-based software*

Even though SnapEdit supports the PNG format, it failed to preserve the transparency of the areas outside the wavy edges when image was saved. All transparent pixels were replaced with black, and as a result the restored photograph had a black frame around its borders.

## 5. CONCLUSIONS

With the advancement of artificial intelligence, numerous opportunities for substantial improvements across various domains of human activity are emerging. Notably, the availability of AI-based software solutions for photo editing is expanding, including specialized tools for the restoration and reconstruction of old photographs.

In this study, we evaluated various free web-based AI tools that can be used for reconstructing old and damaged photographs. We selected black-and-white and colour analogue photographs that exhibited typical types of damage associated with poor storage and handling. These photographs were digitized and processed using AI-based applications to assess the effectiveness of the AI in restoring the details and characteristics of the original image.

It became evident that AI-based applications allowed for rapid processing while delivering visually pleasing results. As a comparison, an outcome that would require several hours of meticulous work by a skilled professional can be achieved within seconds.

On the other hand, tested solutions adequately removed damage only on the low frequency image areas – monochrome surfaces, simple textures and areas containing little details. On the other parts of photographs, AI applications failed to reconstruct details properly. The missing parts were either smoothen out, or wrongly interpreted and, therefore, recreated in a different manner.

The AI tools also demonstrated a tendency to remove grain from the photographs, likely mistaking it for noise. Since the grain is a fundamental characteristic of a film image, its removal can affect the authenticity of the photograph.

Furthermore, in most of the applications, the results of automatic processing required manual adjustments. This was particularly true for the reconstruction of details, colour and contrast correction. As a result, the effectiveness of the restoration heavily depends on the user's skill to identify errors and their willingness to take a detailed approach in marking specific areas for processing.

Taking into account that all the tested AI-based solutions were designed to be very intuitive and easy to use, we believe that they are great solution for amateurs who want to quickly and efficiently bring their old photographs back to life. These tools can be of great help to professionals as well, for quicker processing of the areas that do not contain many significant details. Nonetheless, for intricate restoration work, manual intervention and expert skill are still irreplaceable.

## 6. ACKNOWLEDGMENTS

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