The Application of Ai Technology in Post-Processing of Photography

Wenying Guo[1], Wenjie Zhang[2], Jiaxing Zhang[3], Shiwei Zhang[4], Ling Jin[5]

wenyingguo@stud.tjut.edu.cn[1], 491852417@qq.com[2], 2532006915@qq.com[3], tf20130806@stud.tjut.edu.cn[4], Jinling-2021@outlook.com[5]

Tianjin University of Technology Main Campus, Tianjin (China)

Abstract. In this study, we conducted an in-depth investigation into the application of AI technology in post-processing of photography. We have categorized AI applications into three distinct groups: AI Enhancement and Restoration, AI Image Recognition, and AI Generation. AI Enhancement and Restoration techniques possess remarkable advantages in improving image quality. Within this domain, we have delved into the remarkable optimization effects that can be achieved through techniques such as defogging, super-resolution, colorizing old photos, and removing scratches. Subsequently, we examined the utilization of AI Image Recognition technology in post-processing of photography. We emphasized its application in areas such as topic detection, background elimination, and face recognition. Finally, we examined the performance of AI Generation in generating images. These images not only exhibit a high degree of realism but also have the ability to achieve effects such as style conversion based on user preferences, significantly enhancing the diversity of visual expression.

Keywords: Photography, post-processing, AI image processing, computational intelligence, and deep learning General and reference

1 Introduction

In the field of photography, the rise of artificial intelligence (AI) has brought profound impacts, transforming the traditional model of photography industry from shooting to post-processing. We classify AI applications in post-processing photography into three main themes: AI enhancement and restoration, AI image recognition, and AI generation. AI enhancement and restoration techniques mainly include AI defogging, AI super-resolution, AI colorizing old photos, and AI removing scratches. These technologies utilize advanced algorithms and machine learning to meticulously adjust and optimize images, meeting users' demands for high-quality images. Additionally, AI image recognition technology plays a pivotal role in post-processing of photography. It can accurately detect and classify various elements in images, such as subject detection and face recognition. These technologies provide photographers with powerful editing tools, helping them better understand and edit individual elements in images. Moreover, AI image generation technology brings revolutionary innovations to photography. It breaks the limitations of traditional photography, creating more diverse and rich visual expressions. AI image generation technology enables photography to not only document but also create, express, and innovate.

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2 AI image enhancement and restoration

2.1 AI dehazing

For images taken in heavy fog conditions, where details are unrecognizable, removing the fog to restore a clearer and more authentic image is essential. Compared to traditional techniques, deep learning methods are often more adaptable to complex scenes and uneven fog conditions, able to handle situations that traditional methods struggle with. Currently, image dehazing technology can effectively reduce the image blur caused by fog, making objects in the image clearer and more visible, especially in the details of distant objects. As shown in Figure 1, AI has restored the color shifts caused by fog and haze in the image, improving local contrast and making the colors in the image more authentic and accurate.

Figure 1. A set of AI defogging effect images

In the field of image dehazing, a classic algorithm is DehazeNet[1], which is an early network that uses deep learning for dehazing. It estimates the atmospheric degradation model using CNNs through end-to-end training. The model takes a hazy image as input and outputs a transmission map, and then uses the atmospheric degradation model to restore the haze-free image. Currently, deep learning-based image dehazing may have limited dehazing effects in complex scenarios such as uneven fog or strong lighting changes.

2.2 AI scratch removal

AI can analyze the pixels in an image and make adjustments to fill in the missing parts of old or damaged photos, such as scratches and creases. It can also remove dust, spots, and stains from occluded areas of the image and enhance the color, clarity, and facial features of the subjects. It has good performance in detail processing, making old and damaged photos visually appealing. Figure 2 shows the effect of AI scratch removal and restoration.

Figure 2. Left: Original Image Right: Result after using AI scratch removal and restoration.

Compared to traditional scratch removal techniques, AI is faster, more efficient, and provides more accurate restoration results, closely resembling the original appearance of the photos. However, the effectiveness of AI scratch removal depends on the complexity of the damage, and it may not produce satisfactory results for highly challenging or rare damages. In the case of traditional single-image super-resolution, blurring issues may occur in complex textures. Reference-based super-resolution (RefSR) utilizes information from high-resolution images to assist in image restoration, simplifying the generation of difficult textures into a search and transfer process, significantly improving visual effects. Additionally, a novel texture transfer network for image super-resolution (TTSR) [2]effectively searches and transfers high-resolution texture information from low-resolution inputs, fully utilizing reference images to address blurring and artifacts. Currently, software such as VanceAI Photo Restorer, RestoroAI, Photoshop with AI Enhancements, etc., have implemented these functions, enabling fast and effective photo restoration and enhancement, even for complex damages.

2.3 AI colorization of old photographs

This technology uses deep learning and computer vision algorithms to analyze image features and pixel information, identify objects and scenes in the picture, and add appropriate colors to them, so as to realize automatic coloring of old photos. Mainstream software such as Adobe Photoshop and Prisma have applied AI old photos coloring technology, enabling users to quickly realize the coloring of old photos through simple operations. Compared with the cumbersome manual coloring, the automatic coloring of AI greatly improves efficiency and accuracy, and coloring old photos more accurately, avoiding color deviation caused by human factors. At present, this technology can achieve realistic natural color restoration, accurately coloring the characters and objects in old photos, and making old photos glow with new vitality, as shown in Figure 3.

Figure 3. Comparison of effects after AI old photos coloring

Among the classic algorithms in this field, the Convolutional Neural Network (CNN) algorithm based on deep learning is the most famous. CNN[3] algorithm learns and extracts features from image data by using deep learning algorithms, and then accurately restores the color of gray images according to the learned patterns and rules, so as to realize automatic coloring of old photos. However, AI old photos coloring technology also has defects. The colorization of complex images and details may not be accurate enough, manual intervention may be required for certain types of old photos, and the current technology cannot fully meet the personalized color needs of users. In addition, for large-scale and high-pixel old photo processing, the processing speed and cost of AI technology are also one of the current challenges.

2.4 AI super-resolution

This technique analyzes the content and structure of the image to produce a higher resolution image to improve detail and clarity, most commonly through super-resolution technology. Mainstream software such as Adobe's Photoshop, Lightroom, and Premiere Pro, as well as Topaz Labs' Gigapixel AI and Video Enhance AI, have already applied this technology. Compared with traditional technologies, AI resolution enhancement technology has many improvements. Traditional methods tend to be based on interpolation algorithms, but can result in blurry or distorted images. AI technology is able to better understand image content, producing clearer and more realistic high-resolution images. Currently, this technology can multiply from low to high resolution while maintaining the accuracy of image details and structure, making subtle textures and edges sharper, and improving the clarity of each frame of the video, as shown in Figure 4.

Figure 4. The effect of AI with 8x resolution (from 200 x 200 px to 1,600 x 1,600 px).

Classical algorithms in this field include super-resolution algorithms using convolutional neural networks (CNNs), such as SRCNN[4], ESPCN, and SRGAN. These algorithms are based on the principle of deep Xi, and the super-resolution reconstruction of images is achieved by constructing deep neural networks. However, due to the large amount of training data and computing resources required to improve the resolution of AI technology, the hardware requirements are high, and the effect of AI technology may not be ideal for some extreme cases, such as extremely low resolution or extremely complex images.

3 Ai image recognition

AI Image Recognition technology is a technique that utilizes AI algorithms to analyze, process, and recognize images. Current applications mainly include background elimination, object detection, and face recognition.

The purpose of AI object detection is to identify one or more objects in an image and distinguish them from the background. Many post-production software such as Photoshop, Snapseed, etc. have supported this technology, providing intelligent selection, background defocus, object enhancement and other functions. Typical traditional methods for AI object detection include HOG detector, DPM , etc., which rely on manual feature description. Currently, more popular AI object detection methods include R-CNN[5], Fast R-CNN , etc., which significantly improve processing speed compared to traditional methods. However, current AI object detection technology has limitations such as limited dataset category numbers, single scenes, weak generalization ability of algorithms, and unstable results.

AI background elimination can automatically detect the subject boundary at the center of the image and erase the background. It is suitable for various matting scenes such as people, animals, furniture, clothing, etc. as shown in Figure 5. Deep learning-based methods achieve a more automated image background removal process compared to traditional methods such as GrabCut. Mask R-CNN is a relatively classic deep learning model that combines object detection and instance segmentation, able to generate object bounding boxes, category labels, and pixel-level segmentation masks simultaneously. However, it is less accurate when dealing with small objects compared to large ones. In complex backgrounds or when multiple objects overlap, it is difficult to segment the target accurately and retain details.

AI face recognition is a technology that utilizes AI algorithms to automatically recognize or verify faces in images or videos. Face recognition technology has been widely used in post-production photography such as Photoshop's face liquefaction and perceptual content filling, FaceApp's transformation of gender, age, and expressions of faces as shown in Figure 5 Traditional face recognition technology mainly consists of combinations of manually designed features and machine learning techniques. However, CNN-based face recognition technology can automatically learn features and extract deeper and higher semantic features. However, there are still limitations in AI face recognition. The quality of training data affects recognition accuracy and may produce inaccurate results for certain populations or scenarios. Additionally, the application of AI face recognition involves risks of privacy breaches due to the use of biometric information.

Figure 5. The original right: the effect of AI after removing the background

4 AI image generation

4.1 AI text-to-image generation

Artificial intelligence (AI) has been widely used in image editing software to generate high-quality and exquisite illustrations based on user-input text descriptions. This technology not only adds creative and artistic elements to photographic images, but also enables faster and easier realization of creative ideas compared to traditional image processing techniques. The latest versions of mainstream photographic post-processing image editing software, such as Adobe Photoshop, have integrated AI-generated image technology. Currently, AI-generated image technology has supported ultra-long text description words, diverse cultural identification, rich color output, and more, generating highly realistic images while supporting high-frequency detail processing and good generation controllability. However, from a

technical perspective, AI-generated image still needs further improvement in terms of realism and controllability. The figure 6 shows the AI-generated image based on the description "The end of the highway is a big mountain."

Figure 6. The image generated by AI based on the description "The end of the highway is a big mountain"

4.2 AI image-to-image translation

AI Image-to-Image Translation technology can perform image filling and style transformation based on the original image. According to brief text descriptions and circled shapes, it automatically fills content while maintaining color and style consistency with the surrounding environment, achieving painting-style generation filling and automatic image expansion effects. Currently, software such as DALL-E, Stable Diffusion[6], Adobe Firefly have integrated generative filling functions, and Adobe Firefly supports generative expansion functionality. In October 2023, Adobe further improved its generative filling function, allowing users to insert or replace objects in a few seconds by simply inputting text, generating high-quality image results. AI Image-to-Image Translation technology can also achieve various artistic style conversions and supports custom style image style migration. It extracts styles from uploaded existing images and applies them to generate images with consistent styles. Mainstream platforms such as Baidu AI Open Platform and Stable Diffusion have applied this technology. In October 2023, Baidu AI Open Platform supports style migration processing using custom style images and images to be processed, and provides 30 artistic styles for selection. In November 2023, Adobe's style-match feature can create large-scale images with consistent styles and appearance, which is applied in branding and graphic design. Style migration technology uses CNN to apply the style of one image to the content of another image. Figure 7 shows the effect of style transfer replacing the season.

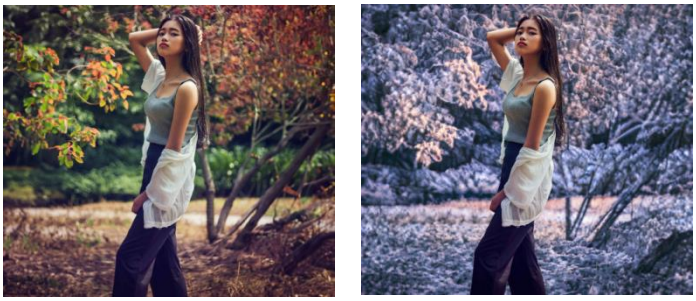

Figure 7. The figure below demonstrates the effect of replacing the season through style transfer

Currently, most applications of AI in image processing are presented in an integrated mode, combining AI image recognition, AI image enhancement and repair, and AI generation. The Stable Diffusion platform is an example of an open-source image processing platform. As shown in Table 1, our experimental team has tested various models on this platform and summarized their usage methods and formulas.

Table 1. The test data for the Stable Diffusion open-source platform

Preprocessor	SD Large Model	Function
openpose	chilloutmix_NiPrunedFp32Fix(lisa_v1)	specify body posture
openpose_hand	chilloutmix_NiPrunedFp32Fix(koreanDollLikeness)	specify body posture and gesture
openpose_faceonly	chilloutmix_NiPrunedFp32Fix(koreanDollLikeness)	specify facial information (face shape, features, expression, etc.)
openpose_full	realisticVisionV51_v51VAE(Lora-Custom-ModelLiXian)	specify all postures (body posture, gesture posture, facial posture, etc.)
lineart_anime	anythingv5	the color filling of animation line art
lineart_coarse	dreamlabsoilV2_v2	the color filling of sketches
lineart_realistic	anythingv5	the conversion of real people into two-dimensional art
mlsd	realisticVisionV51_v51VAE	housing Design (Structural Constraints)
depth_leres++	realisticVisionV51_v51VAE	housing Design (Depth Constraints)
seg_ofade20k	realisticVisionV51_v51VAE	housing Design (Item Constraints)
invert	_____	custom Architecture Design
shuffle	anythingv5	style Control
reference	anythingv5	rich Subject (Static to Dynamic, Cartoon Reproduction)
ip2p	anythingv5	add Special Effects

5 Conclusion

The integration of artificial intelligence (AI) into photography post-processing has emerged as a pivotal aspect of technological advancement. Traditional image processing methods, facing challenges in addressing intricate issues, have been revolutionized by the introduction of AI. This innovation not only deepens our comprehension of image content but also significantly supports restoration and enhancement efforts, catering to the escalating demands of users.

Beyond its applications in photography, AI has also exhibited promise in video generation, advertising design, and logo creation. A notable instance is the successful utilization of AI by Ito En, a renowned Japanese tea company, in creating the female protagonist for its green tea beverage advertisement. This exemplifies the untapped potential and economic viability of AI in photography post-processing.

6 Outlook

Looking ahead, the continued evolution and optimization of AI technology foretell an even broader scope for its application in the photography domain. As technology advances and application scenarios expand, AI is poised to occupy a more central role in photography, enabling the creation of more expressive and engaging image content. Furthermore, as AI becomes more accessible and cost-effective, an increasing number of enterprises and individuals will be able to harness its benefits in photography post-processing. This trend is expected to breathe new life into the photography industry, driving its continued growth and innovation.

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