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A GAN-based Denoising Method for Chinese Stele and RubbingCalligraphic Image

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Abstract

Chinese calligraphic images have important artistic and historical values. However, subjected to hundreds of years of naturalweathering, corrosion and man-made destruction, Chinese calligraphic images inevitably contain some special noise, such asdotted noise, flake corrosion noise and scratch noise. How to denoise this special noise is a challenge for digital preservation ofChinese calligraphic. In this paper, we propose an end-to-end calligraphic image denoising algorithm based on a well-designedgenerative adversarial network. The generator contains a recurrent network and a denoising autoencoder. By introducing anattention mechanism, we use a recurrent network with multiple progressive network units to generate a noise attention map.Through the noise attention map, the denoising autoencoder can restore the noisy calligraphic image into a clean image withreduced noise or even no noise. The extensive experiments results show that the results of our method are better than thoseof other comparison methods in terms of visual effects, PSNR and SSIM.

Keywords Chinese calligraphy · Generative adversarial network · Image denoising · Calligraphic images   
1 IntroductionChinese calligraphy is an important carrier of Chinese cul-ture, which is the unique cultural treasure of the Chinesenation [31]. The digitization of Chinese calligraphic artworks is an important means for the protection of calligraphicart. Thus, high-quality Chinese calligraphic images derivedfrom steles and rubbing are of great significance to the digitalprotection and inheritance of calligraphic arts. However, sub-jected to hundreds of years of natural weathering, corrosionand man-made destruction, the original Chinese calligraphicimages inevitably contain a lot of noise. These noises, asmarked with some read circles in Fig. 1, are classified intothree categories: dotted noise, flake corrosion noise andscratch noise. Excessive noises not only affect the integrityof calligraphic strokes, making the fonts difficult to identify,but also affect the esthetics of calligraphic art. Therefore, i is necessary to study how to denoise the Chinese calligraphyimage [21].Image denoising is the most basic and important one inimage processing. In the past, researchers focused on usingtraditional method to denoise images. Filtering techniquesas the main denoising algorithms, there are mean filtering[13, 14, 19], median filtering [26], non-local mean filtering[1], Gaussian filtering [7, 17], Wiener filtering [3], Lapla-cian pyramid filtering [5] and so on. Liu et al. [37] proposeda new sparse coding optimization model for image denoising.In addition, the KSVD method is introduced in [20] for cal-ligraphic image denoising. Although these methods removethe dotted noise very well, they cannot accurately distinguishbetween a stroke and a scratch around the font. Therefore,they cannot effectively eliminate flake corrosion and scratchnoise around the font.

In recent years, image denoising methods based on deeplearning have been continuously proposed, and the resultshave been remarkable. Zhang et al. [35] designed a DnCNNmodel that combines batch normalization and residual learn-ing strategies to deal with additive white Gaussian noise withunknown noise levels. Subsequently, Zhang et al. [34] pro-posed a fast and flexible FFDNet model, which achieves agood compromise between inference speed and noise reduc-tion performance. For real-image denoising, Guo et al. [12]

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