Performance Evaluation of Single Image Super-Resolution Models Based on Perceptual Quality and Naturalness

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Abstract

Single-image super-resolution (SISR) constitutes a fundamental challenge in image processing, focusing on the reconstruction of high-resolution images from their low-resolution counterparts while enhancing fine details and textures to achieve superior quality of visual perception. Estimating a high-resolution image from its low-resolution counterpart is an ill-posed inverse problem, since there are infinitely many solutions that satisfy the measurements. SISR has seen significant advancements and gained significant attention with the introduction of deep learning-based models, particularly Generative Adversarial Networks (GANs). With varying performance of the different architectures across different metrics, evaluating the performance of these models requires a comprehensive analysis of both perceptual quality and naturalness. This study evaluates five deep learning-based pre-trained and fine-tuned SISR models (GANs, PSNR-Large, PSNR-Small, Noise-Cancel, and LapGAN) using perceptual and naturalness metrics (BRISQUE, CLIPIQA, CLIPIQA+, TRES, NIQE, and ILNIQE) to identify optimal architecture for visual quality enhancement. Datasets used for evaluation are DIV2K and other benchmark datasets. Results indicate that GAN-based models excel in perceptual quality metrics (CLIPIQA, TRES), suggesting superior high-frequency detail generation. It achieved a 2.5% improvement in CLIPIQA score compared to Noise-Cancel and a 1.1% improvement in NIQE score compared to LapGAN. This study provides insights into the trade-offs between naturalness and perceptual quality in SISR models, aiding researchers in selecting appropriate architectures based on application-specific requirements.

Keywords

Deep Learning, Generative Adversarial Networks (GANs), Image Quality Assessment, No-Reference Metrics, Single Image Super Resolution (SISR).