Synergy between Super-Resolution and Deep Learning: An Application on Thin Sections

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Abstract. There is a growing demand for high-resolution (HR) digital rock images for various applications. Image quality is inevitably traded off with acquisition time. This work introduces a novel Attention-UNet based Wasserstein Generative Adversarial Network with Gradient Penalty (WGAN-GP) to rapidly restore low-resolution (LR) thin sections to their clean counterparts. The enhancing resolution workflow includes three main steps. Step 1: Dataset Generation: numerous pairs of LR thin sections and their corresponding HR ones are collected from lab measurements. Step 2: Surrogate Training: Attention-UNet-based WGAN-GP model is trained, in which the generator is composed of an UNet with an attention mechanism, and the loss in each layer is extracted to boost the predictivity. A pre-trained network, called VGG, is employed to enhance the capability of capturing essential features. Step 3: Quality Check: high-fidelity ground-truth HR images are compared to check the predicted high-resolution ones. The proposed Attention-UNet-based WGAN-GP model matches the ground truth with less than 10% error. We further demonstrate its performance with traditional Super-Resolution GAN (SRGAN) and Enhanced Super-Resolution GAN (EDSR). Our proposed method achieves the highest accuracy with the same dataset. The Attention-UNet-based WGAN-GP outperforms other models because 1) the attention mechanism helps the network capture the most relevant features, 2) the residual block's utilization in Res-UNet alleviates the gradient vanishing problem and boosts information exchange across different layers, and 3) the use of WGAN stabilizes the training process by surpassing the Jessen-Shannon divergence. We propose a novel super-resolution approach using Attention-UNet-based WGAN-GP to boost the resolution of 2D thin sections, which is superior to the traditional models regarding accuracy and efficiency. This method enables us to obtain high-resolution rock images for real-time analysis efficiently.