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Real-world image super-resolution for digital rock analysis

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The porous media community extensively utilizes digital rock images for core analysis. High-resolution digital rock images that possess sufficient quality are of great importance, but are sometimes difficult to obtain and suffer from high cost. Super-resolution (SR) approaches enhance the resolution of digital rock images, and provide improved visualization of fine features and structures, aiding in the analysis and interpretation of rock properties, such as pore connectivity and mineral distribution.

However, the majority of the existing SR methods are trained on fabricated datasets, in which the low-resolution images are created by applying a basic and consistent degradation, e.g., bicubic downsampling, to their high-resolution equivalents. And the actual low-resolution images captured from real-world scenarios could be different from the fabricated low-resolution images. Consequently, the SR models trained on fabricated data demonstrate reduced effectiveness when employed in practical situations.

In this study, we construct a real SR dataset by capturing paired low- and high-resolution images of the same rock samples using the scanning electron microscope (SEM) and computed tomography (CT) at multiple resolutions. Additionally, an image registration algorithm is developed to progressively align the image pairs at varying resolutions. Our experiments demonstrate that applying the bicubic downsampling to the high-resolution images, although widely used, is not always a good approximation of the real low-resolution images. The reason behind this can be partially explained by the mechanism in the SEM and CT techniques.

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