Deep Learning for Image Super-Resolution

The goal of image super-resolution (SR) is to restore a visually pleasing high-resolution (HR) image from a low-resolution (LR) input image or video sequence. Image SR has been proved to be of great significance in many applications, such as video surveillance, ultra-high definition TV, low-resolution face recognition and remote sensing imaging. Benefiting from its broad application prospects, SR has attracted huge interest, and currently is one of the most active research topics in image processing and computer vision. Recently due to fast advances in deep learning, deep network-based SR has shown promising performance in certain applications. However, there are still many challenging open topics of deep learning for image SR, e.g. on new objective functions and new network architectures, for large scale images and depth images, and for images with various types of corruption and from new applications. This special issue collected ten papers reporting the state-of-the-art researches in the theory, algorithm, modeling, system and application of deep learning-based SR and demonstrating the latest efforts of relevant researchers.

- **Seddik et al.**

  Generative collaborative networks for single image super-resolution

  In this first paper, Seddik *et al.* state that recent VGG losses using a pre-trained architecture with ImageNet cannot work well when facing the images quite different from those in ImageNet. To tackle this problem, the authors present a general framework named generative collaborative networks (GCN), where the idea consists of optimizing the generator in the feature space of a feature extractor network. The included generator and extractor are collaborative in the sense that the latter can help the former by constructing discriminative and relevant features.

- **Rad et al.**

Benefiting from multitask learning to improve single image super-resolution

The second paper, by Rad *et al.*, introduces a novel approach to the single image super-resolution (SISR) problem, utilizing categorical information to obtain SR with more realistic textures. By leveraging an encoder architecture with extra semantic information, the proposed algorithm can super-resolve a given image by using multitask learning simultaneously for image SR and semantic segmentation.

- **Choi et al.**

Deep learning-based image super-resolution considering quantitative and perceptual quality

The third paper investigates the tradeoff between the quantitative and perceptual qualities of super-resolved images, which correspond to the similarities to the ground-truth images and the naturalness, respectively. In order to improve the perceptual quality of the upscaled images while preserving the conventional quantitative performance, the authors employ a deep network for multi-pass upscaling in company with a discriminator network and two quantitative score predictor networks. By using the aesthetic scores predictor and the subjective scores predictor, the model can generate perceptually improved images. The discriminator reinforces model to focus on fine details while the multi-pass upscaling helps the model to learn various upscaling patterns.

- **Wang et al.**

Ultra-dense GAN for satellite imagery super-resolution

The forth paper proposes an ultra-dense GAN (udGAN) for image SR, where they reform the internal layout of the residual block into a two-dimensional matrix topology. This topology can provide additional diagonal connections so that they can still accomplish enough pathways with fewer layers. The achievable rich connections are flexibly adapted to the diversity of image content, thus leading to improved SR performance.

• **Li et al.**

Deep residual network for highly accelerated fMRI reconstruction using variable density spiral trajectory

In the fifth paper, the authors use deep residual network to reconstruct fMRI data with 20x acceleration via the variable density spiral trajectory. Both the mean square error (MSE) loss in the image domain and the data-consistency in the k-space domain are employed to evaluate the 'distance' between the network output and the ground truth. In addition, the time-frame sharing strategy to take full advantage of the adjacent frames' k-data information is adopted in the reconstruction scheme, which facilitates the learning process and provides better performance.

• **Thurnhofer-Hemsi et al.**

Deep learning-based super-resolution of 3D magnetic resonance images by regularly spaced shifting

In the sixth paper, based on the combination of CNN and regularly spaced shifting mechanism, a method for magnetic resonance image super-resolution is presented. Low resolution images are processed through an SR CNN. The quality of the restored images is increased by applying a regular shifting model to the input images and then recomposing the restoration shifts with high resolution into a consensus.

• **Purohit et al.**

Mixed-dense connection networks for image and video super-resolution

The seventh paper, by Purohit *et al.*, proposes a mixed-dense connection network (MDCN) to maximize the efficiency of super-resolution networks. It is based on the proposed dual link unit, derived from MixNet and reaping the benefits from both residual and dense connections.

• **Li et al.**

Deep recursive up-down sampling networks for single image super-resolution

In the eighth paper, Li *et al.* propose the deep recursive up-down sampling networks (DRUDN) for SISR. In DRUDN, an original LR image is directly fed without extra interpolation. Then, the authors use the sophisticated recursive up-down sampling blocks (RUDB) to learn the complex mapping between the LR image and the HR image. At the reconstruction stage, the feature map is up-scaled to the ideal size by a de-convolutional layer.

- **Zhou et al.**

Deep fractal residual network for fast and accurate single image super resolution

The ninth paper introduces a novel, fast method for SISR by using a deep fractal residual network (DFRN). Fractal blocks are used to learn and combine different hierarchical features, so that the proposed DFRN can generate finer features for reconstructing HR images.

- **Lin et al.**

SCRSR: An efficient recursive convolutional neural network for fast and accurate image super-resolution

In the last paper, Lin *et al.* propose a recursive efficient deep convolutional network for fast and accurate single-image SR. A split-concatenate-residual (SCR) block is proposed to reduce computation and parameters. With the downsampling block and the upsampling block, the authors significantly reduce computational complexity and enlarge the size of the receptive field. Specifically, a two-level recursive learning method is proposed to improve accuracy by increasing depth without adding weight parameters.

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