ETSIP001 - ResGAN: A Low-level Image Processing Network to Restore Original Quality of JPEG Compressed Images

Abstract

In this paper, we describe a unified deep learning based approach for low-level image processing, in particular, image denoising, image deblurring and compressed image restoration. The proposed method is based on conditional generative adversarial network. The generator network is composed of multiple layers of convolution and de-convolution operators, and learns end-to-end mappings from raw images to processed images for tasks of the low-level image processing. The convolutional layers capture the abstraction of image contents. Deconvolutional layers have the capability to upsample the feature maps and recover the image details. To deal with the problem of deeper networks tending to be more difficult to train, we propose symmetrically linking convolutional and deconvolutional layers with bi-skip-layer connections, with which the training converges much faster and attains better results. Given a target image x, our goal is to obtain a task-specific estimate of x based on the observed image y. We formulate the total loss Ltotal as follows: Ltotal = Ladv + λLcont, where Lcont is the content loss function which measures the difference between x and our estimate x˜. In our model, we use WGAN-GP as the objective: Ladv = E x∼Pr [D(x)]− E x˜∼P g [D(˜ x)]+λ E xˆ∼Pxˆ [(||∇xˆD(ˆ x)||−1)2]. And we do a little modification to the total loss when optimizing the generator: max G − E x˜∼P g [D(˜ x)] + λ · Lcont. Having considered a serious problem for gradient-based optimization algorithms, we innovatively propose multi-objective optimization framework and formulate our content loss by combining L1 loss and perceptual loss together: Lcont = α x˜ − x 1 + β F(˜ x) − F(x) 2, where α and β are coefficients used to unify the magnitudes. The content loss induces the direction of optimization to remain the similarity of the images' content, which is consistent with the direction of the adversarial loss that encourages the generator network to prefer solutions that reside on the manifold of target images by trying to fool the discriminator network. In other words, the adversarial loss and the content loss supplement each other. Experimental analysis on three low-level image processing tasks, including image denoising, image deblurring and compressed image restoration show that our proposed low-level image processing network achieves good performance. To our knowledge, this is the first approach that achieves good performance on most low-level image processing tasks using a unified network architecture.