World Academy of Science, Engineering and Technology
International Journal of Bioengineering and Life Sciences
Vol:11, No:10, 2017

Deep Learning Based on Image Decomposition for Restoration of Intrinsic Representation

Authors : Hyohun Kim, Dongwha Shin, Yeonseok Kim, Ji-Su Ahn, Kensuke Nakamura, Dongeun Choi, Byung-Woo Hong

Abstract : Artefacts are commonly encountered in the imaging process of clinical computed tomography (CT) where the artefact refers to any systematic discrepancy between the reconstructed observation and the true attenuation coefficient of the object. It is known that CT images are inherently more prone to artefacts due to its image formation process where a large number of independent detectors are involved, and they are assumed to yield consistent measurements. There are a number of different artefact types including noise, beam hardening, scatter, pseudo-enhancement, motion, helical, ring, and metal artefacts, which cause serious difficulties in reading images. Thus, it is desired to remove nuisance factors from the degraded image leaving the fundamental intrinsic information that can provide better interpretation of the anatomical and pathological characteristics. However, it is considered as a difficult task due to the high dimensionality and variability of data to be recovered, which naturally motivates the use of machine learning techniques. We propose an image restoration algorithm based on the deep neural network framework where the denoising auto-encoders are stacked building multiple layers. The denoising auto-encoder is a variant of a classical auto-encoder that takes an input data and maps it to a hidden representation through a deterministic mapping using a non-linear activation function. The latent representation is then mapped back into a reconstruction the size of which is the same as the size of the input data. The reconstruction error can be measured by the traditional squared error assuming the residual follows a normal distribution. In addition to the designed loss function, an effective regularization scheme using residual-driven dropout determined based on the gradient at each layer. The optimal weights are computed by the classical stochastic gradient descent algorithm combined with the back-propagation algorithm. In our algorithm, we initially decompose an input image into its intrinsic representation and the nuisance factors including artefacts based on the classical Total Variation problem that can be efficiently optimized by the convex optimization algorithm such as primal-dual method. The intrinsic forms of the input images are provided to the deep denosing auto-encoders with their original forms in the training phase. In the testing phase, a given image is first decomposed into the intrinsic form and then provided to the trained network to obtain its reconstruction. We apply our algorithm to the restoration of the corrupted CT images by the artefacts. It is shown that our algorithm improves the readability and enhances the anatomical and pathological properties of the object. The quantitative evaluation is performed in terms of the PSNR, and the qualitative evaluation provides significant improvement in reading images despite degrading artefacts. The experimental results indicate the potential of our algorithm as a prior solution to the image interpretation tasks in a variety of medical imaging applications. This work was supported by the MISP(Ministry of Science and ICT), Korea, under the National Program for Excellence in SW (20170001000011001) supervised by the IITP(Institute for Information and Communications Technology Promotion).

Keywords : auto-encoder neural network, CT image artefact, deep learning, intrinsic image representation, noise reduction, total variation

Conference Title : ICMIE 2017 : International Conference on Medical Imaging and Engineering

Conference Location : Osaka, Japan

Conference Dates : October 09-10, 2017

Open Science Index, Bioengineering and Life Sciences Vol:11, No:10, 2017 publications.waset.org/abstracts/75915.pdf