CT enhancer for radiotherapy

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Abstract

Computer tomography (CT) scan is a 3D image used for delineations and dose calculation in radiotherapy. However, artefacts from metals may obscure the underlying anatomy and distort the dose calculation by causing voxel values (Hounsfield Unit (HU)) to deviate from the physical measurements. Besides, low resolution (less than 512x512) scans may hinder delineations. In this project, the potential of an image restoration AI model to remedy metal artefacts and increase resolution is explored.
Our approach involved simulating degraded CTs to train a DL model. First, raw "clean" CT images (without artefact) were selected from two head-and-neck clinical trials (NCT02999087, NCT0357641) if they had $\geq$512$\times$512 pixels and no metal ($\leq$3060 HU). Second, metal artefact simulation or resolution decrease is applied. The resolution simulation was resizing the scan to a resolution between 200 and 300. In the metal artefact simulation (3), a metal is placed inside a clean image and the image is recalculated. Recalculation entailed converting HU values to linear attenuation coefficients, from which X-ray attenuation is calculated yielding the sinogram. The image then was reconstructed from the sinogram Third, a CT enhancing DL model was trained to remove those degradations within a classical training-validation-test scheme. For each training sample, the input was a triplet of neighbouring simulation-degraded images, and the target was the raw clean image matching the triplet's middle image. The model architecture was Deep compression autoencoder. . This model was chosen to exploit the benefits of both transformers and convolutional networks. The huber loss between the output and the target was minimised by a AdamW optimiser.

The CT enhancer's performance was evaluated on test dataset simulated the same way as training data with three metrics: means of mean absolute error, peak signal-to-noise ratio(PSNR), multi scale structural similarity index measure (SSIM).

The scores on the simulated test dataset was: mean absolute error: 6.39, peak signal to noise ratio: 72.82,multi scale structural similarity index: 99.74%. The model has shown low error, good contrast, and very good fidelity to the reality.
In this project, we trained a deep compression autoencoder to apply SR and MAR on CT scans simultaneously. The results have shown that SR and MAR can be simultaneously performed by a single DL model. A formal validation protocol for measuring the impact on individual case reviews is under development.

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