CLAIMS

1. A method for training a diagnostic imaging device to perform medical diagnostic imaging with reduced contrast agent dose, the method comprising:

a) performing diagnostic imaging of a set of subjects to produce a set of images comprising, for each subject of the set of subjects, i) a full-contrast image acquired with a full contrast agent dose administered to the subject, ii) a low-contrast image acquired with a low contrast agent dose administered to the subject, where the low contrast agent dose is less than the full contrast agent dose, and iii) a zero-contrast image acquired with no contrast agent dose administered to the subject, wherein the full-contrast image, the low-contrast image and the zero-contrast image are acquired using a common imaging modality;

b) pre-processing the set of images to co-register and normalize the set of images to adjust for acquisition and scaling differences between different scans;

c) training a deep learning network (DLN) with the pre-processed set of images by applying zero-contrast images from the set of images and low-contrast images from the set of images as input to the DLN and using a cost function to compare the output of the DLN with full-contrast images from the set of images to train parameters of the DLN using backpropagation.

2. The method of claim 1 wherein the cost function is an MAE loss function, or a mixture loss function with non-local structural similarities.

3. A method for medical diagnostic imaging with reduced contrast agent dose, the method comprising:

a) performing diagnostic imaging of a subject to produce i) a low-contrast image acquired with a low contrast agent dose administered to the subject, where the low contrast agent dose is less than a full contrast agent dose, and ii) a zero-contrast image acquired with no contrast agent dose administered to the subject, wherein the low-contrast image and the zero-contrast image are acquired using a common imaging modality;

b) pre-processing the low-contrast image and zero-contrast image to co-register and normalize the images to adjust for acquisition and scaling differences;

c) applying the low-contrast image and the zero-contrast image as input to a deep learning network (DLN) to generate as output of the DLN a synthesized full-dose contrast agent image of the subject;

wherein the DLN has been trained by applying zero-contrast images and low-contrast images as input and full-contrast images acquired using the common imaging modality with the full contrast agent dose as reference ground-truth images.

4. The method of claim 3 wherein

the low contrast agent dose is less than 10% of the full contrast agent dose.

5. The method of claim 3 wherein

performing diagnostic imaging comprises performing angiography, fluoroscopy, computed tomography (CT), ultrasound, or magnetic resonance imaging.

6. The method of claim 3 wherein

performing diagnostic imaging comprises performing magnetic resonance imaging, and the full contrast agent dose is at most 0.1 mmol/kg Gadolinium MRI contrast.

7. The method of claim 3 wherein

the DLN is an encoder-decoder convolutional neural network (CNN) including bypass concatenate connections and residual connections.

8. A method for medical diagnostic imaging, the method comprising:

a) performing diagnostic imaging of a subject to produce a first image acquired with a first image acquisition sequence and a second image acquired with a second image acquisition sequence distinct from the first image acquisition sequence, where zero contrast agent dose is administered during the diagnostic imaging, wherein the first image and the second image are acquired using a common imaging modality that is magnetic resonance imaging (MRI);

b) pre-processing the first image and the second image to co-register and normalize the images to adjust for acquisition and scaling differences;

c) applying the first image and the second image as input to a deep learning network (DLN) to generate as output of the DLN a synthesized full-dose contrast agent image of the subject;

wherein the DLN has been trained by applying zero-contrast images acquired using the common imaging modality with zero contrast agent dose with different imaging sequences as input and full-contrast images acquired using the common imaging modality with a full contrast agent dose as reference ground-truth images.