Experiments showed that the output by processing images using different CNNs is accurately improved. This adds ideas and contributions to the state-of-the-art CNN architecture, improving the solution. Although previous work states that most current software-based approaches are model-based, their model is not able to accurately capture the phenomenon of scatter radiation.

**OBJECTIVES**

- In X-ray imaging, scattered radiation can produce noise and a number of artifacts that greatly undermine the image quality. This problem can be solved by using anti-scatter grids. However, solution can be costly and hard to operate.
- Problem: Find a cheaper solution that can be easily implemented and performs equally if not better as the anti-scatter grid solution.
- Previous work: Most current software-based approaches are model-based. However, their model is not able to accurately capture the phenomenon of scatter radiation.

**APPROACH**

- CNNs (Convolutional neural networks) have been widely used as the state of the art in the last few years for many image processing tasks. They are trained to learn a mapping from the input space to the output space. In our case, the input is the scattered image and the output is the ground truth (the image obtained by using an anti-scatter grid).
- We exploit the behavior of the CNN in the frequency domain combined with the state-of-the-art architectures, so that we can achieve more optimal results. Specifically, the main contributions of this work are listed below.
- Splitting the signal into different frequency bands and processing each band independently yields better results than processing the signal as a whole when using CNNs.
- For high frequency bands, one can improve the results by dilating the image before passing it through the convolutional neural network. For the other bands, this process is not necessary because the CNN already outputs almost optimal images.

**METHODOLOGY**

- We convolve a smooth Gaussian kernel with the image, which outputs the low frequency component. Then we use the following equation for the high frequency component.

\[
H_f = I - L_f
\]

where, \(I\) is the image, \(L_f\) and \(H_f\) are the low and high frequencies, respectively.
- We perform one more splitting on the high frequency component. Thus, we end up with \(X_{low-frequency}\), \(X_{high-low-frequency}\), and \(X_{high-high-frequency}\) (Figure 5).
- \(X_{low-frequency}\) generally does not need to be processed due to its similarity in input (scattered image) and output (ground truth).
- \(X_{high-low-frequency}\) is processed with a CNN.
- Training \(X_{high-high-frequency}\) is not as simple because that component contains the most scattered radiation. To ameliorate this problem, we dilate the signal. So that the frequency is decreased. We dilate by linear interpolation.
- Finally, we add up all the frequency components.

**RESULTS**

- Experiments were performed using an arbitrary architecture. We also test our claims on different architectures. The results were consistent.
- In figure 7 we can observe how the contrast on the white strip was greatly enhanced. Moreover, Figure 8 shows exactly how the "bump" is recovered in the reconstructed image from practically no bump in the scattered image.

**CONCLUSION**

- In this work, we showed that CNNs can outperform current approaches at doing scatter correction.
- Additionally, we explored the ideas of splitting into frequency bands and dilation, which both were proven to improve the result produced by the CNN.

**BIBLIOGRAPHY**


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![Convolutional Neural Network Structure](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 1: Anti-scatter grid illustration. Taken from http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 2: Convolutional Neural Network Structure](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 2: Convolutional Neural Network Structure](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 3: a) Loss for same frequency band with and without splitting. b) Loss for high frequency band with and without dilation](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 3: a) Loss for same frequency band with and without splitting. b) Loss for high frequency band with and without dilation](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 4: Comparison among ground truth, scattered image (noisy image), Yingying’s [2] result and the CNN result](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 4: Comparison among ground truth, scattered image (noisy image), Yingying’s [2] result and the CNN result](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 5: Different frequency bands of an image](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 5: Different frequency bands of an image](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 6: Left: Ground truth, Center: Scattered image, Right: CNN result](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 6: Left: Ground truth, Center: Scattered image, Right: CNN result](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 7: Zoomed in regions. Left: Ground truth, Middle: Scattered image, right: CNN result](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 7: Zoomed in regions. Left: Ground truth, Middle: Scattered image, right: CNN result](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 8: Intensity vs pixel location of Figure 7.](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)

![Figure 8: Intensity vs pixel location of Figure 7.](http://www.upstate.edu/radiology/education/rsna/radiography/scattergrid.php)