

# Cycle-GAN 을 활용한 X-Ray 보안 영상 데이터셋 향상

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## Cycle-GAN for Enhancing X-Ray Security Image Datasets

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Abstract

The inherent imbalance in X-ray security image data poses a significant challenge for computer vision algorithms in this field. Many previous studies have overlooked this issue, limiting practical applications. This paper explores the impact of using Cycle-GAN for image augmentation to enhance the performance of computer vision algorithms on an imbalanced X-ray dataset. Cycle-GAN was used to convert camera images of threat objects into X-ray images. These synthesized images were combined with background X-rays to augment the dataset.

### I . Introduction

X-ray imaging is a well-established technology used in security systems at ports, borders, and certain establishments. It enables nondestructive detection of concealed threats through X-ray image analysis by trained inspectors. However, the increase in passenger travel and goods shipment demands higher efficiency and accuracy from these systems. Computer vision algorithms, particularly Convolutional Neural Networks (CNNs), have been adapted for X-ray security applications to automate detection tasks and assist human inspectors[1,2].

Recent deep learning applications in X-ray imagery for security and medical diagnostics use techniques like denoising, super-resolution, and contrastive learning to enhance image quality and accuracy. Convolutional neural networks (CNNs) improve feature detection and classification over traditional methods. Strategies like modifying activation functions, transfer learning, and image inpainting address training challenges. These methods are applied to disease diagnosis, material discrimination, and software engineering, significantly advancing deep learning in computer vision[3,4].

Imbalanced datasets, where threat images are rare, bias conventional learning algorithms. Image augmentation, including transformations and Generative Adversarial Networks (GANs), can help balance datasets by creating new images[5,6]. This study investigates using GAN-based image augmentation to improve threat detection models on a large, imbalanced X-ray dataset. New X-ray images of threats are generated and combined with benign images to enhance the training set.

### II . Method

For image generation, we used Cycle-GAN to produce new X-ray images of threat objects. Initially, we collected camera images of threat objects from Kaggle and various websites. The Cycle-GAN[7] model was then used to convert these camera images into X-ray images by learning the mapping between the two domains. The Cycle-GAN comprises two sets of GANs that translate images between camera and X-ray domains, ensuring that the generated X-ray images closely resemble real X-ray images. The newly generated X-ray threat images were then combined with negative sample images to create realistic X-ray security images. This method addresses class imbalance and enhances the dataset, improving the performance of the threat detection model. Additionally, using camera images to generate X-ray images allows researchers and scientists to obtain X-ray security images for experiments without the high cost of using real X-ray scanners.

Our generated images using Cycle-GAN demonstrated superior performance compared to other methods. As shown in Figure 1, the quality of the synthesized X-ray images is significantly higher, closely resembling real X-ray images, which provides a more robust and diverse dataset for training threat detection models. The Cycle-GAN approach effectively addresses the inherent class imbalance in X-ray security datasets by generating a balanced set of high-quality images that include both normal and threat objects. Incorporating these synthesized images into the training dataset enhances the model's detection capabilities by providing a deeper understanding of the visual characteristics of threats.

Additionally, this method is highly advantageous for researchers and practitioners, allowing the generation of high-quality X-ray security images without the expense of real X-ray scanners, significantly reducing costs and logistical challenges. The use of Cycle-GAN ensures that the synthesized images retain critical details and realistic features, essential for accurate training, leading to better performance in practical applications such as airport security and border control. In summary, our use of Cycle-GAN for generating synthetic X-ray images improves dataset quality and diversity, addresses class imbalance, enhances model performance, and offers a cost-effective alternative to traditional data acquisition methods, holding significant promise for the future of X-ray security imaging and related fields.



Figure 1: Our Proposed Cycle-GAN output

### III. Conclusion

In this paper, we demonstrated the effectiveness of using Cycle-GAN-based image augmentation, or image synthesis, on improving detection performance in a practical X-ray security image dataset. Our image synthesis approach with Cycle-GAN was designed to maintain the internal distribution of threats within the training set, avoiding bias during the learning phase.

Our findings indicate that Cycle-GAN-based image synthesis significantly enhances the model's ability to distinguish between normal and threat objects by providing a diverse set of synthesized images. Additionally, combining image synthesis with image transformation further improved performance by enlarging the dataset and introducing new perspectives.

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### REFERENCES

- [1] Shao, Fangtao, et al. "Exploiting foreground and background separation for prohibited item detection in overlapping X-Ray images." *Pattern Recognition* 122 (2022): 108261.
- [2] Yagoub, Bilel, Mahmoud SalahEldin Kasem, and Hyun-Soo Kang. "Enhancing X-ray Security Image Synthesis: Advanced Generative Models and Innovative Data Augmentation Techniques." *Applied Sciences* 14.10 (2024): 3961.
- [3] Yu, Jiahui, et al. "Free-form image inpainting with gated convolution." *Proceedings of the IEEE/CVF international conference on computer vision*. 2019.
- [4] Yagoub, Bilel, et al. "Single energy x-ray image colorization using convolutional neural network for material discrimination." *Electronics* 11.24 (2022): 4101.
- [5] Qiu, Lingteng, et al. "Ethseg: An amodel instance segmentation network and a real-world dataset for x-ray waste inspection." *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition*. 2022.
- [5] Jeong, Jiwoong J., et al. "Systematic review of generative adversarial networks (GANs) for medical image classification and segmentation." *Journal of Digital Imaging* 35.2 (2022): 137-152.
- [7] Dumagpi, Joanna Kazzandra, and Yong-Jin Jeong. "Evaluating gan-based image augmentation for threat detection in large-scale xray security images." *Applied Sciences* 11.1 (2020): 36.