**Option #1: Working with a Generative Adversarial Network**

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**Generative Adversarial Networks**

Generative Adversarial Networks (GANs) have emerged as a powerful tool in the field of machine learning, particularly for generating realistic and high-quality synthetic data. This paper explores the diverse applications of GANs across multiple industries, highlighting their benefits and contributions in each use case. Four pertinent use cases are identified and discussed, showcasing versatility and impact of GANs in various industrial domains. The benefits of using GANs in each application are elucidated, including improved efficiency, enhanced creativity, cost savings, and data augmentation. The analysis aims to demonstrate the transformative potential of GANs in shaping the future of industrial processes and applications.

**Fashion**

The use of GANs in the fashion and retail industry offers several benefits. By employing GANs for image synthesis, retailers can enhance the online shopping experience by allowing customers to virtually try on clothes and accessories. This not only improves customer satisfaction but also reduces the need for physical try-ons, leading to cost savings and increased efficiency. Additionally, GANs enable retailers to create diverse virtual product catalogs without the need for costly photoshoots, resulting in significant cost reductions. The use of GANs in fashion and retail also facilitates faster product development cycles, as designers can iterate and make improvements based on virtual prototypes, reducing time-to-market. According to Pecenakova et al. (2022), the authors introduced a generative framework called FitGAN to address the challenging problem of size and fit in the fashion industry. They demonstrated the effectiveness of FitGAN in learning internal representations of fit and shape properties from 2D images using visual clues.

The study showcased the ability of FitGAN to generate realistic images and transformations of an article’s fit and shape in the 2D image space, even with limited categorical fit and shape labels. The authors also explored semi-supervised conditionings at scale. The findings of this work open up promising avenues for future research.

**CyberSecurity**

According to Dutta et al. (2020), the application of GANs in security is considered a powerful step forward and a valuable tool in cybersecurity. Although research in this area is relatively new, GANs have shown promise in generating new defense techniques for cyber intrusion, malware detection, and secure image steganography. The use of GANs in security attacks has primarily focused on malware generation for intrusion detection systems, providing insights into previously unknown attacks and aiding in the update of defense mechanisms. The survey conducted by Dutta et al. (2020) encompasses a wide range of GANs research in cybersecurity, including image steganography, neural cryptography, security protocols, detection systems, intrusion detection, and security analysis. The authors discuss various GAN architectures and their variations employed by researchers to address security scenarios effectively. GANs have been used to enhance surveillance, strengthen detection systems, and generate new and unknown attacks that reveal vulnerabilities in defense systems. These attacks can be utilized to fortify software against future threats. GANs have the potential to generate tests for both known and unknown attacks, leading to significantly stronger computers, computer-based products, and IoT devices. Although the use of GANs in security is still in its early stages, it should progress rapidly.

**Healthcare**

The use of synthetic data generation has gained significant attention in the medical field, particularly in healthcare applications where data availability and privacy regulation pose challenges. La Salvia et al. (2022) proposed synthetic data assembly to overcome limitations related to limited dataset size and data sharing restrictions imposed by data protection regulations. The generation of synthetic data allows researchers to access increased and anonymous data, facilitating the development and acceleration of deep learning methodologies in clinical practice. The authors engineered a proof-of-concept utilizing a Deep Convolutional GAN (DCGAN) architecture to generate hyperspectral (HS) medical data for skin lesion analysis. The GAN framework was trained using a small-sized dataset of RGB images from the HAM10000 dataset, followed by transfer learning with HS images. The generated synthetic data was evaluated using the Frechet Inception Distance (FID) metric, which measures the similarity between the real and synthetic data distributions. The results showed a FID score of 17.37, indicating good synthesis and similarity between the two datasets. To assess the usability of synthetic data, a ResNet18 model was trained exclusively on synthetic data and tested on real images. The accuracy, precision, recall and F1 score of the classification model were all above 80%, demonstrating the comparability between synthetic and real images. The spectral signatures of the generated images were also evaluated qualitatively and quantitatively. The study by La Salvia et al. (2022) highlights the potential of synthetic data generation in healthcare, specifically for skin lesion analysis. It paves the way for leveraging deep learning techniques in situations where the number of labeled samples is limited. Future research in this area may focus on exploring novel GAN architectures for medical HS images and extending conditional GANs to generate different tumor etiologies, going beyond benign and malignant lesions.

**Autonomous Driving**

Uřičář et al. (2019) conducted research on the application of GANs in the context of autonomous driving, specifically focusing on the classification and enhancement of soiling and adverse weather in images. The problem involves identifying image deterioration caused by factors such as soiling (e.g., mud splashes, dust) on the camera lens or adverse weather conditions (e.g., heavy rain, snow). The objectives of addressing this problem are twofold: 1) recognizing the type of soiling on the camera lens to initiate the cleaning system, and 2) enhancing image quality through despoiling techniques like dehazing and deraining. The researchers chose to use GANs for this problem due to the difficulty and expense of obtaining relevant annotated data manually. GANs offer the potential for semi-supervised learning, making them well-suited for this task. They conducted a proof-of-concept experiment, categorizing images into “clean” and “soiled” classes. By employing CycleGAN, they observed that the generator learned to recognize the soiled parts of the image and successfully desoil the image. They also obtained a generator capable of introducing soiling to clean images. Although the dataset used for the experiment was relatively small, the desoiling generator learned to introduce shadows of the car body, reflecting the prevalence of such shadows in the “clean” category. The soiling generator learned that the weather was typically cloudy in the “soiled” category. This experiment demonstrated the potential of GANs for soiling and adverse weather classification/enhancement tasks and generated hypotheses about obtaining semantic segmentation of soiling without explicit annotations. To address the limitations of generating variable output, the researchers attempted another experiment using the MUNIT approach. MUNIT’s ability to separate content from the style offered control over generated images, aiding classifier training.

However, due to the lack of high-quality data, the results from the MUNIT experiment contained artifacts and did not meet their satisfaction. Nonetheless, they considered it a promising avenue for further exploration. Uřičář et al.’s (2019) research highlights the potential of GANs in solving the problem of soiling and adverse weather classification/enhancement in autonomous driving. They suggest that with minimal annotation efforts, GANs can contribute to addressing this challenge. The researchers continue their research in this domain, focusing on various directions for further investigation.

**Conclusion**

In conclusion, GANs have demonstrated remarkable potential and have proven to be a valuable asset in multiple industries. In the fashion and retail sector, GANs enable virtual try-on experiences, diverse product catalogs, and faster product development cycles. The application of GANs in cybersecurity enhances defense techniques, aids in malware detection, and strengthens intrusion detection systems. In healthcare, GANs facilitate the generation of synthetic data, improving data availability and privacy while accelerating the development of deep learning methodologies. Lastly, in autonomous driving, GANs offer solutions for the classification and enhancement of soiling and adverse weather, contributing to improved safety and image quality. The advancements showcased in these domains highlight the versatility and transformative potential of GANs. As research and development in GANs continue, we can expect even more innovative applications and breakthroughs in the future, further revolutionizing these industries and beyond.

**References**

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